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CITY OF LOS ANGELES

THIRD ANNUAL REPORT

OF THE BUREAU OF THE

LOS ANGELES AQUEDUCT

November 30th, 1908

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1908

REALITY PUBLISHING COMPANY
120 N. Spring St., Los Angeles, Cal.

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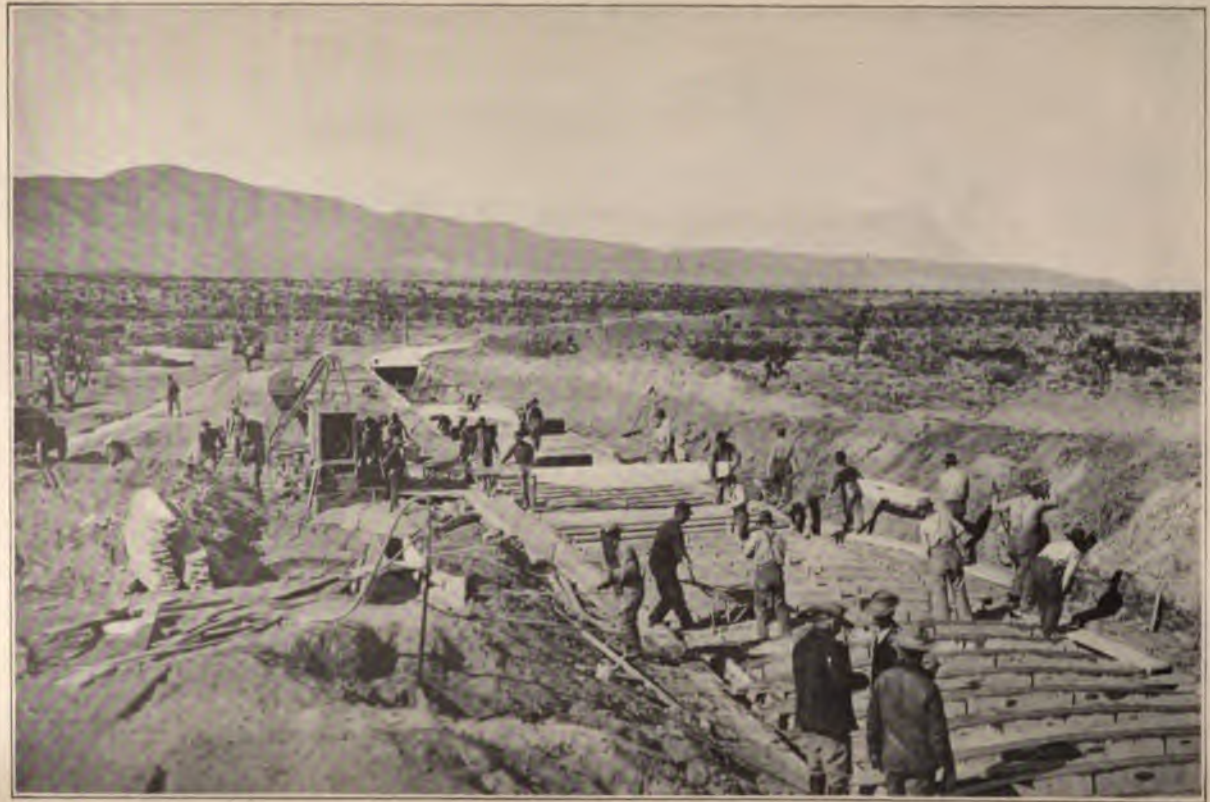


PUTTING CONCRETE COVER ON THE CONDUIT—MOJAVE DIVISION.

BOARD OF PUBLIC WORKS OF THE CITY OF LOS ANGELES

BUREAU OF THE LOS ANGELES AQUEDUCT

WM. MULHOLLAND, *Chief Engineer.*
J. B. LIPPINCOTT, *Asst. Chief Engineer.*

Los Angeles, California, December 1, 1908.

The Honorable Board of Public Works,
City of Los Angeles.

Gentlemen: The Annual Report herewith submitted by our Engineering Department of the Los Angeles Aqueduct is the first to record substantial progress in the actual construction work of the Aqueduct. It would be difficult to find a case in the annals of important engineering construction where the saying "Well begun is half done" would apply with greater force.

The preliminary work necessary to properly enable construction work to begin has been appalling in its magnitude and expense, and must have taxed the patience of your honorable body severely, but it was felt that better and more economic progress could be made with all the accessories in the completed state in which they now are, than to begin in a condition of unpreparedness and run the risk of impeding the work later. The nature and extent of this work is exhaustively dwelt on and minutely described in this report, and we feel confident that the progress on the actual building of the Aqueduct in the near future will fully justify the great expense incurred in this preparatory work.

Included in the report is not alone a description of the work so far accomplished, but a prospectus of the plan of actual construction for the coming fiscal year, together with an estimate of its cost for the guidance of the financial end of the undertaking. It will be seen that an effort is made to make construction accord with our financial ability, and due consideration was also given to the capacity of the cement plant to produce material for the work outlined.

The confusion attendant upon the building up of an efficient organization to properly carry on this great project is now rapidly disappearing, and all the departments are moving with less friction and greater efficiency than at first, as the men become accustomed to their several duties. Most of the employees, and especially those in executive charge of work, have evinced a most commendable spirit of interest, not alone in connection with their several duties, but in the larger aspect of the project itself. It is pleasing to be able to report that this is the result of natural enthusiasm, rather than through any action of the superior officers to encourage such a feeling. In fact, it is to be regretted that those in the upper class of executive charge have had very little time for semi-social contact with their co-laborers in the lesser positions.

So far as the work has progressed, there has been everything to encourage the belief that it will be ultimately completed within the time and cost originally estimated.

Thanking your honorable body for your kindly co-operation and encouragement to myself and co-laborers, I remain,

Yours very respectfully,

WM. MULHOLLAND.
Chief Engineer.

ENGINEERING DEPARTMENT
LOS ANGELES AQUEDUCT

Engineering Organization.

The Chief Engineer is the executive and professional head of all branches of the Aqueduct having construction work in charge. All division engineers and superintendents, consulting engineers, experts, office engineer and construction clerks report either directly or indirectly to him. The assistant chief engineer represents the chief engineer in his absence, and assists him in all branches of the organization.

The work is divided into the following principal divisions:

Divisions—Name.	No.	Extent or Description of Division.
Long Valley	1	Mt. Diablo Base Line to South Boundary of Mono County.
Owens Valley	2	North Boundary Inyo County to and including Cottonwood Creek.
Olancha	3	Cottonwood Creek to and including Haiwee Reservoir, Hogback and Haiwee Creeks.
Rose Valley	4	South End of Haiwee Reservoir to Little Lake.
Grapevine	5	Little Lake to North End of Indian Wells Siphon.
Freeman	6	North End of Indian Wells Siphon to Red Rock Summit.
Jawbone	7	Red Rock Summit to Pinto Hills.
Mojave	8	South End of Pine Canyon to North End A. V. Cottonwood Siphon.
Antelope Valley	9	North End A. V. Cottonwood Siphon to Fairmont Reservoir.
Elizabeth Lake	10	Fairmont Reservoir and Long Tunnel to Diversion in San Francisquito Canyon.
Saugus	11	Diversion in San Francisquito Canyon to and including San Fernando Reservoirs.
Railroads	12	All matter pertaining to any railroads.
Cement Works	13	All subjects pertaining to Cement Plants.
Power Plants	14	All subjects pertaining to Power Plants and Electrical distribution.

It is the general intention, modified by incident conditions, to place an assistant engineer or superintendent in charge of each of the divisions under construction. These divisions, in turn, are divided into sections with a superintendent in charge of each section. These sections are from five to ten miles in length, depending on the difficulty of the work and physical conditions. Special details to work requiring expert knowledge are frequently made, as for instance, the sinking of artesian wells, or the installation of telephone lines.

The work of sinking wells and laying pipe lines for a water supply for domestic and construction purposes for the Aqueduct work has been in charge of Mr. O. A. Rathbun. Mr. E. F. Scattergood has been employed as consulting electrical engineer, and as such has designed the power plants and lines and the electrical equipment along the line. He has also been placed in executive charge of the telephone system, the hydro-electric power plants and the electric power transmission lines. Mr. Roderick MacKay, mechanical constructor, has had charge, in an advisory and executive capacity of the design, selection of equipment and installation of mechanical plants. He is also in executive charge of the Mojave machine shop. Mr. E. Duryee, cement expert, has designed and installed the cement plant for the Aqueduct near Tehachapi. He has charge of the operation of this plant and the testing of the cement.

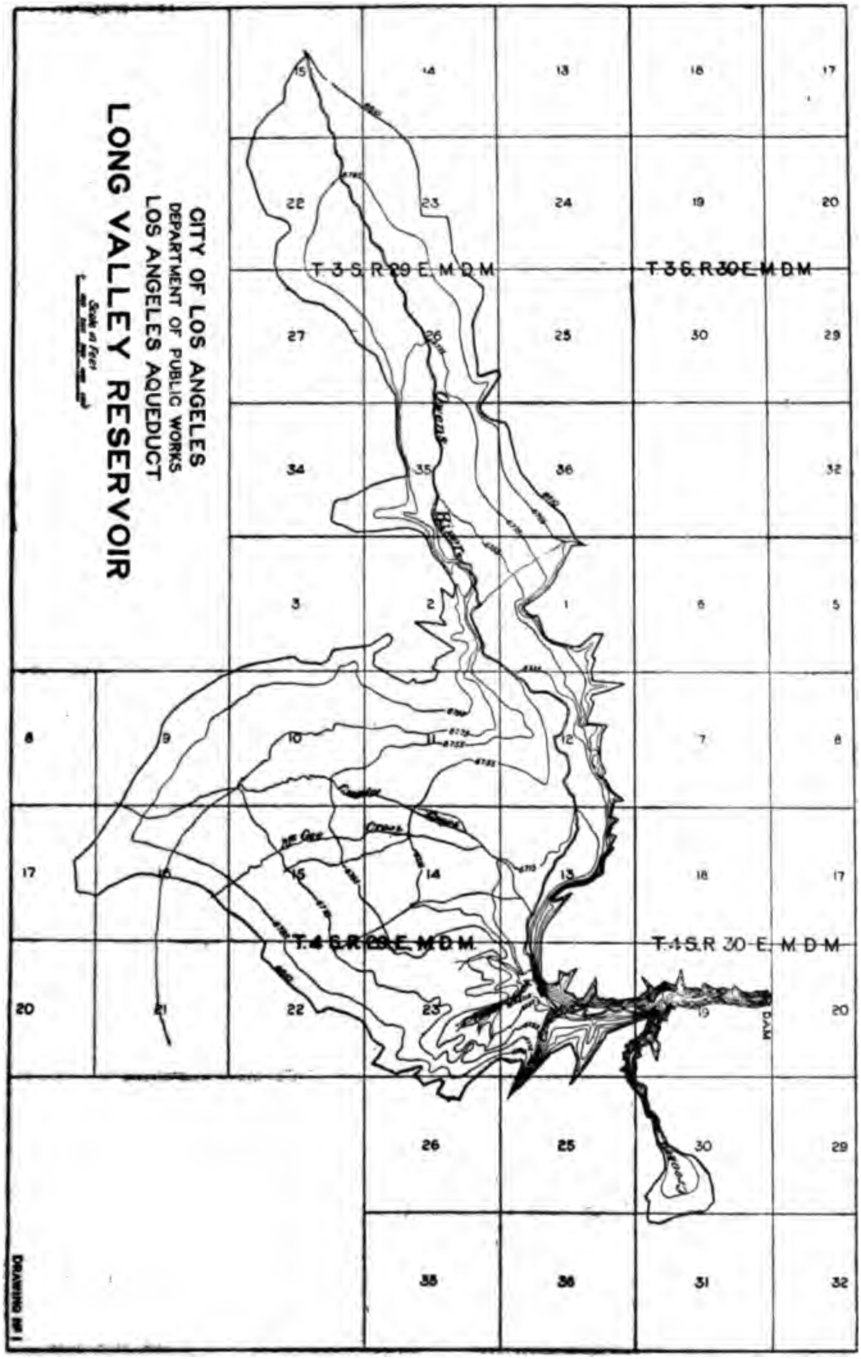
In the Los Angeles office, Mr. H. A. Petterson, assistant engineer, has charge of the drafting room and is in direct charge of the designing of structures. He is responsible for all records, plans, estimates and computations. Assistant engineers, from time to time, are assigned to office duty as assistants to the chief engineer, both in order to facilitate the work in the office, and to have the men become familiar with office as well as field conditions.

All engineers and superintendents in responsible charge of work are required to make ten day and monthly reports as to the cost and progress of their work. These reports pass over the desk of the chief engineer for his review.

GENERAL PLANS OF CONSTRUCTION.

The primary purpose of the proposed system of reservoirs and conduits, known as the Los Angeles Aqueduct, is to deliver the largest possible amount of the available water supply of the Owent River Water Shed to the head of the San Fernando Valley, whence this supply will be distribtuted for domestic and irrigation purposes.

In the study of the project it has been found that electrical energy can be developed on a large scale. This electrical development though a valuable adjunct may be called a secondary consideration. It is discussed in detail in another part of this report. The first consideration


CITY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
LOS ANGELES AQUEDUCT
LONG VALLEY RESERVOIR
Scale in Feet
T. 3 S. R. 29 E. M. D. M.
T. 3 S. R. 30 E. M. D. M.
T. 4 S. R. 29 E. M. D. M.
T. 4 S. R. 30 E. M. D. M.
Owens River
DAM
DRAWING Nº 1

in the design of the Aqueduct was to determine the quantity of water available together with the size and class of conduit which the City could afford to construct. This is treated in detail under the subject "Water Investigation," page 90. It has been found that a continuous flow of 400 second feet, or 20,000 miner's inches, can be relied upon. This is equivalent to almost 260,000,000 gallons per day.

It is undesirable to construct a conduit of capacity sufficient to carry the maximum daily flow. If the Aqueduct were of sufficient size to carry the average discharge for the Owens River alone for the month of July, 1906, it would require a capacity of 2182 second feet. The cost of such an aqueduct would be prohibitive. It is evident then that some other method than that of increasing the conduit capacity must be resorted to in order that the primary purpose of the Aqueduct may be fulfilled, viz: the delivery of the largest possible amount of the available supply of the Owens River Watershed to the head of the San Fernando Valley. Storage reservoirs are evidently required. Were it not for the existence of the natural reservoir sites, the project of bringing water from the Owens Valley to Los Angeles in the quantity contemplated, would be far more difficult.

RESERVOIRS.

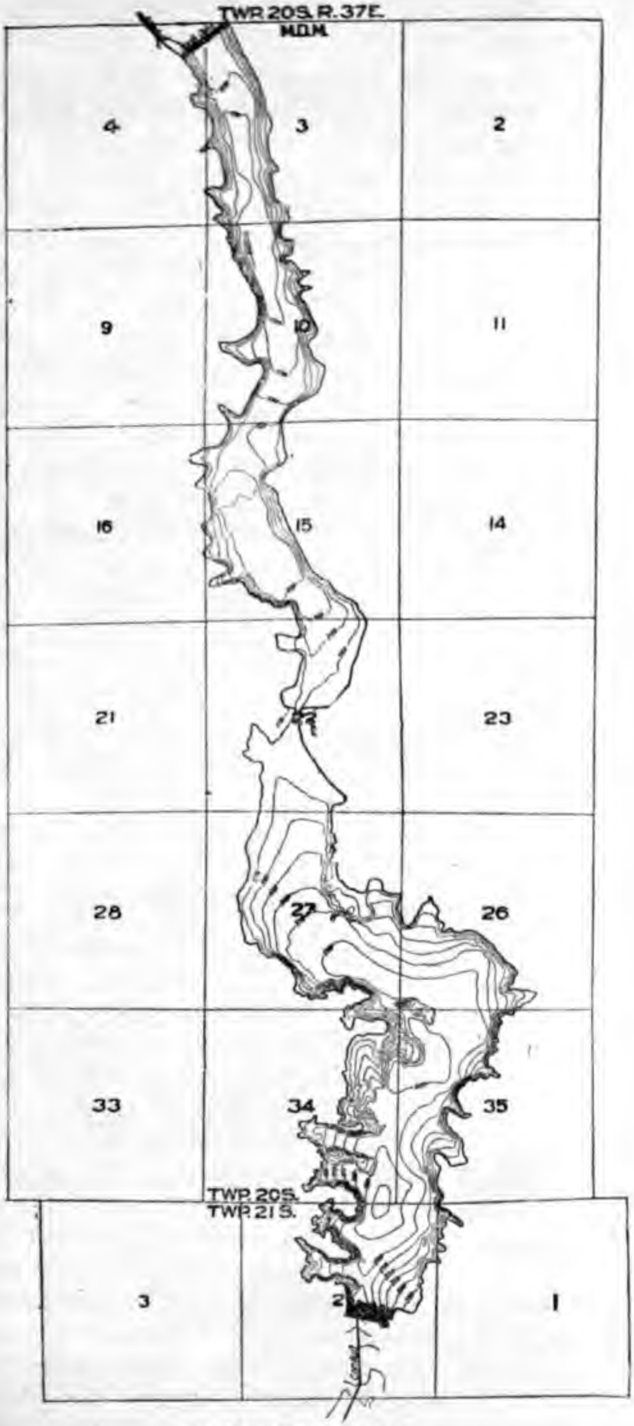
Yearly Regulation.

The proposed site for the Long Valley Reservoir is in Long Valley. This reservoir is so located that it can control the flow during years of excessive discharge of the Owens River and its upper tributaries, McGee, Convict, Crooked and Rock Creeks. Water so impounded may be held for dry seasons. The availability of the Long Valley Reservoir as an annual storage reservoir for the Aqueduct was considered in the First Annual Report. There the statement is made that the maximum storage requirements of the reservoir is 240,000 acre feet. The hydrographic study considered the period from 1851 to 1906: an interval of 55 years.

The capacity of the reservoir with a dam 140 feet in height is 260,000 acre feet and with a dam 150 feet in height is 304,980 acre feet. Hence with a dam 140 feet in height, the Long Valley Reservoir is competent to perform its function of yearly regulation. For a topographic map of this reservoir site see drawing No. 1.

Monthly Regulation.

The site proposed to be utilized as a reservoir for seasonal regulation of stream discharge is located in Haiwee Meadows, some eight miles south of the southerly extremity of Owens Lake. The diversion



CITY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
LOS ANGELES AQUEDUCT.

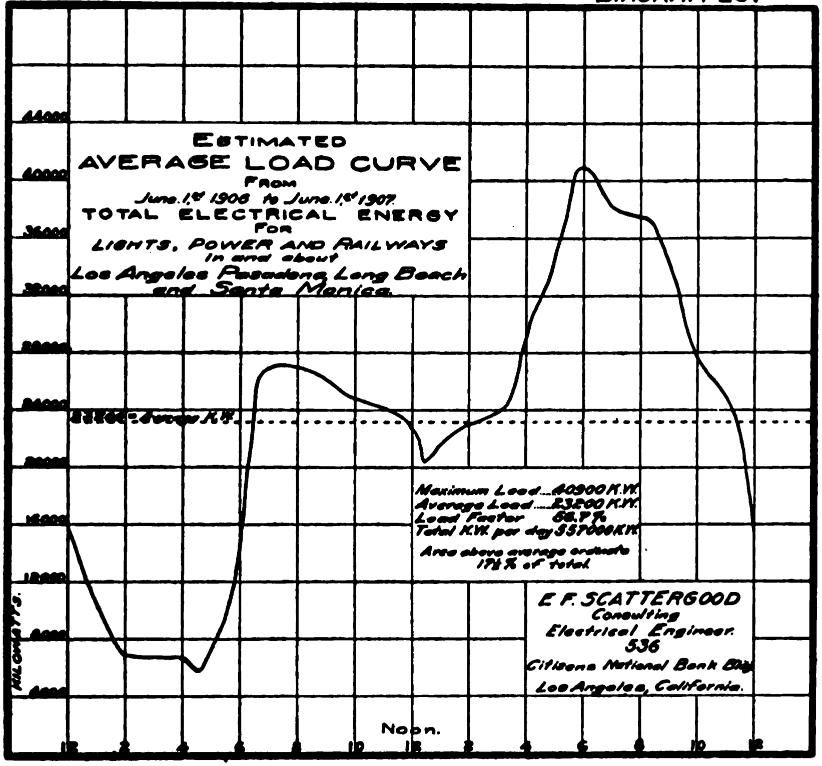
HAIWEE RESERVOIRS

DRAWING No. 2

dam on Owens River will be constructed about 12 miles north of the town of Independence. A diversion canal is now being built to convey the flow of the river and its tributaries to the Haiwee Reservoir. The capacity of this canal will be 800 second feet at the intake and will gradually increase in capacity to 900 second feet to provide for the additional waters of the tributary streams below the headworks. The conduit from Haiwee to Fairmont Reservoir is designed to carry a continuous flow of 430 second feet. The 30 second feet additional capacity is given so as to permit of the accumulation of water in the Fairmont Reservoir. Hence the Haiwee Reservoir must have sufficient capacity to store the increment of flow received from the diversion canal and deliver a continuous draft of 430 second feet. The capacity of the reservoir with a dam 80 feet in height is 63,800 acre feet, or sufficient without any inflow to supply 430 second feet for two and one-half months. It has capacity sufficient to receive a continuous inflow of 900 second feet for two months and seven days while delivering through its outlet 430 second feet. Hence there are short periods of time when a portion of the floods will run to waste. When the Long Valley Reservoir is built, however, it will control the flow of the Owens River, and its upper tributaries. The two reservoirs working in conjunction will be adequate to deliver the continuous supply estimated upon. For topographic map of Haiwee Reservoir see Drawing No. 2.

Power Reservoirs.

Beginning at Haiwee Reservoir the main conduit will convey the water to Fairmont Reservoir, located in the foothills on the south side of Antelope Valley. This reservoir has a capacity of 7620 acre feet with a dam 105 feet in height. While much smaller than either the Long Valley or Haiwee Reservoir, its capacity is adequate for the function it will perform, i. e.,—regulating the flow through the power conduit to meet hourly fluctuations in the demand for power. This conduit will eventually be constructed from the south end of Elizabeth Tunnel through a series of short tunnels and steel pressure pipe to the first power house in San Francisquito Canyon about eight miles southwest of Fairmont Reservoir. This whole system will be under hydrostatic pressure in order to utilize the total head from the water surface of the Fairmont Reservoir. The bottom of the Elizabeth Tunnel at its north portal in Fairmont Reservoir is 85 feet below the surface when the reservoir is full. The elevation of the water surface in the reservoir is 3035 and the proposed elevation of the water wheels in the first power house is 2145, giving a gross head of 890 feet. Of this, DIAGRAM 13.


ESTIMATED
AVERAGE LOAD CURVE
FROM
June 1st 1906 to June 1st 1907
TOTAL ELECTRICAL ENERGY
FOR
LIGHTS, POWER AND RAILWAYS
in and about
Los Angeles Pasadena Long Beach
and Santa Monica.
44000
40000
36000
32000
28000
24000
23200=Average K.W.
20000
16000
12000
8000
4000
KILOWATTS.
Maximum Load...40900 K.W.
Average Load.....23200 K.W.
Load Factor 56.7%
Total K.W. per day 557000 K.W.
Area above average ordinate
17½% of total.
E. F. SCATTERGOOD
Consulting
Electrical Engineer.
536
Citizens National Bank Bldg.
Los Angeles, California.
Noon.
12
2
4
6
8
10
12
2
4
6
8
10
12

approximately 44 feet will be used in friction losses when the power conduit is carrying its maximum flow of 1000 second feet. Hence a peak load of 77,000 H. P. can be developed from this first power house. The average development for each twenty-four hours will be 34,000 horse power. From the tail race of this first power house, the water may be conveyed by a second power canal 41,350 feet in length to a steel penstock leading to the second power house. The net head for this plant is 578 feet and the maximum power development for a peak load will approximate 52,500 H. P. while the daily average development will be 22,600 H. P.

From the tail race of the second power house the conduit leading to Dry Canyon Reservoir is 14,400 feet in length and will have a capacity of 1,000 second feet. The capacity of Dry Canyon Reservoir is 1325 acre feet with a dam 55 feet in height. The province of this reservoir is to regulate back to a normal flow the fluctuating discharges through the power plants so as to reduce the size of the Aqueduct below.

The daily inflow into Fairmont Reservoir will be that carried by the Aqueduct from Haiwee,—namely: 430 second feet. The outflow from the reservoir, however, will vary with the power demand, which in turn depends upon the consumption for lighting and industrial purposes. Diagram 13 shows the present load factor for Los Angeles and vicinity from June 1, 1906, to June 1, 1907. The flow of water in the power conduit will vary from less than 80 second feet to a maximum of 1,000 second feet. The Fairmont Reservoir is also valuable as an insurance against interruptions during the cleaning or repairing of the long line of Aqueduct above it. Its capacity of 7620 acre feet is sufficient to afford a supply of 430 second feet for a period of nine days.

San Fernando Reservoirs.

The Los Angeles Aqueduct terminates at the San Fernando Reservoirs. These reservoirs and any auxiliary construction from San Fernando to Los Angeles will be a part of the distributing system and as such will be built by the Water Department. As the demand for water for all purposes is greater in summer than in winter, these reservoirs will permit of a more efficient use of the Aqueduct. While 400 second feet is continuously discharged into them, 600 second feet may be withdrawn in the four summer months and 300 second feet during the remainder of the year. They will also insure an adequate supply for the City of Los Angeles if the flow through the Aqueduct should be interrupted for a considerable period. There are two

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reservoir sites proposed for which detail surveys and designs for dams have been made and rights-of-way purchased. These are called San Fernando Reservoirs No. 1 and 2. The elevation of the water surface in No. 1 will be 1270 feet; of No. 2, 1135 feet. The required heights of dams will be 120 for Reservoir No. 1, and 125 feet for Reservoir No. 2. The capacities will be for Reservoir No. 1, 15,900 acre feet; for Rersevoir No. 2, 21,050 acre feet. The combined capacity of 36,950 acre feet will be more than four months supply for a population of 1,000,000 with a per capita consumption of 100 gallons per day.

Method of Construction.

The system of reservoirs proposed for the Los Angeles Aqueduct consists then of the Long Valley Reservoir, Haiwee Reservoir, Fairmont Reservoir, Dry Canyon Reservoir and San Fernando Reservoirs No. 1 and 2. The system proposed is distinctly a storage scheme. Active construction has begun on the dam for the Fairmont Reservoir and work is soon to be begun on the Haiwee. All the dams will be of the type known as the Hydraulic Fill Dams with the possible exception of the Long Valley Dam where it is not yet determined that suitable material is available for hydraulic work. This type of dam is being extensively constructed in the West. The Silver Lake Dam built by the City Water Department is of this class. The water for constructing them is available for the Long Valley, Haiwee and Fairmont Reservoirs. The water brought down by the Aqueduct will have to be depended upon in the construction of the San Fernando Dams.

The estimate of the Board of Consulting Engineers did not include the construction of any of the dams mentioned above except at Haiwee. The supply available without them will be adequate to meet the requirements for a number of years to come. As this grows they may be built as circumstances demand.

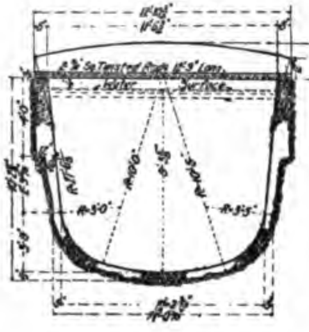
CONDUITS.

The Aqueduct will be made up of the following types of conduit:

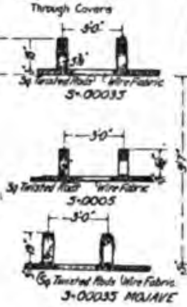
1. Unlined Open Canal.
2. Lined Open Canal.
3. Lined and Covered Canal.
4. Tunnels.
5. Inverted Siphons.
6. Flumes.

The selection of types is determined by the topography of the

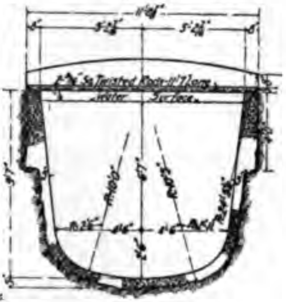
CONDUIT IN
ANTELOPE VALLEY
S=.00035



Longitudinal Section
Through Covers



CONDUIT IN
SAUGUS & A.V. COTTONWOOD
S=.0005

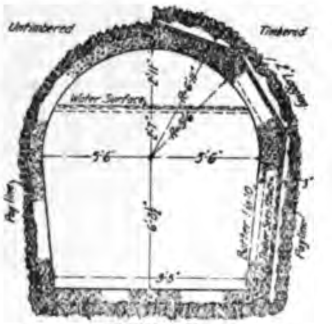


HYDRAULIC PROPERTIES					
	Tunnels		Conduits		
	S=.00035	S=.0005	ANTELOPE	S=.0005	MOJAVE
Capacity	430	438	430	431	433
Velocity	4.64	4.991	4.64	5.26	4.7
Area		87.85	92.79	81.94	92.0
Wetted Perimeter		28.63	25.73	24.61	24.9
Hydraulic Radius		3.065	3.603	3.329	3.7
N		.014	.014	.014	.014
C		127.5	130.5	129	131

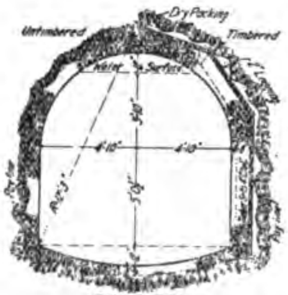
CONSTRUCTION QUANTITIES PER
LINEAL FOOT NORMAL SECTION

TUNNELS					
	Unit	S=.00035		S=.0005	
		Timbered	Untimbered	Timbered	Untimbered
Excavation	Cu. Yds.	6.38	5.38	5.09	4.28
Concrete Lining	Cu. Yds.	1.38	1.05	1.125	.88
Timbering	B.M.	136		96.3	

CONDUITS			Mojave	Antelope
	Unit	S=.0005	S=.00035	S=.00035
Concrete in Conduit	Cu. Yds.	.503	0.55	.562
Concrete in Cover	Cu. Yds.	.187	0.231	.220
Steel in Cover	Lbs.	8.45	15.64	13.56

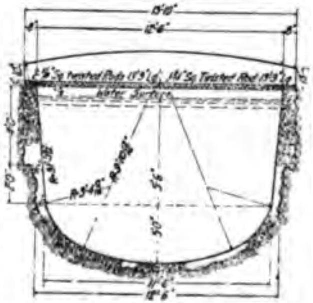


TUNNELS IN
SOUTH ANTELOPE DIVISION
S=.00035



TUNNELS IN
SAUGUS & A.V. COTTONWOOD
S=.0005

CONDUIT IN
MOJAVE DIVISION
S=.00035



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TUNNEL AND CONDUIT SECTIONS
FOR
ANTELOPE, MOJAVE AND SAUGUS DIVISIONS

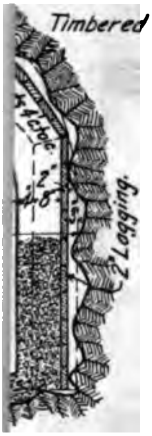
DRAWING NO. 8.

Slopes
Capacity
Velocity
Area
WettedPeri
Hydraulic Ra
N.
C

Cons

Concrete
Concrete
Steel in C
Excavati

Excavatio
Concrete
Timberin



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country traversed and relative economy. This phase will be treated in greater detail under the subject of Surveys. The conduits of the Aqueduct may be divided into three main divisions, each division being made up of several of the types just enumerated. These are:

1. Diversion Conduit.
2. Main Conduit.
3. Power Conduit.

Diversion Conduit.

The diversion conduit may be considered as a new channel of the Owens River, located in a more favorable position for controlling the stream flow and conveying the water to its new destination. The conduit is also favorably located to receive the waters of the tributary mountain streams from Division Creek to Walker Creek. The total length of the diversion conduit from the Intake to its point of inflow into the Haiwee Reservoir is 315,966 feet or approximately 60 miles. From the Intake to the Alabama Hills, the diversion conduit will consist of open, unlined canal for approximately 111,200 feet or 21 miles. The bottom of this section of the canal will be below the ground water plane, hence there is little occasion for its lining with concrete to prevent seepage. From the northern end of the Alabama Hills south, the conduit will be lined with rubble concrete, as the water plane is below the bottom of the canal. See Drawing No. 5 for types of diversion conduit.

Methods and Materials of Construction.

The first twenty-one miles is being excavated by means of a hydraulic dredge. The motive power is 110 K. W. or 147½ H. P. required, is furnished by the City's hydro-electric power plant No. 1 situated on Division Creek. A second dredge, heavier and of somewhat larger capacity than the first is being constructed and will be placed in operation south of Independence. From the rate of progress made by Dredge No. 1, it is estimated that each dredge will make an average progress of 3½ miles per year, or that three years will be the total time required to complete the 21 miles. A second power plant to develop 600 K. W. or 804 H. P. is now under construction on Division Creek to furnish power for Dredge No. 2.

The remaining 39 miles of the diversion conduit will be excavated by power shovels. The material is generally favorable for power shovel work with the exception of the Alabama Hills where the work in some places is on a steep hillside, and the material loose and cemented rock. Here considerable blasting will be required. From the south end of the Alabamas to Haiwee, the excavation will be fairly easy, except that a number of boulder washes must be crossed. Excellent material for concrete work is found quite generally on the line of excavation.

Main Conduit.

The main conduit extends from Haiwee to Fairmont Reservoir, a distance of 138.15 miles and from Dry Canyon to San Fernando Reservoir No. 1, a distance of 11⅔ miles. The conduit between Fairmont and Dry Canyon Reservoirs, a distance of 19.2 miles, is termed "power conduit" as it is an essential part of the power development system. Of this 19.2 miles approximately 7.9 miles are now necessarily being constructed as it is requisite for the delivery of water to the City. If this 7.9 miles is classed as "main conduit," the total length of the conduit is 157.72 miles. Though the estimate of the Board of Consulting Engineers provided for an uncovered conduit a test mile of covered conduit is being built near Mojave to determine whether it is possible to construct the covered Aqueduct at a cost not to exceed the original estimate. The final decision on this question will rest with the Board of Public Works.

TYPES OF AQUEDUCT.

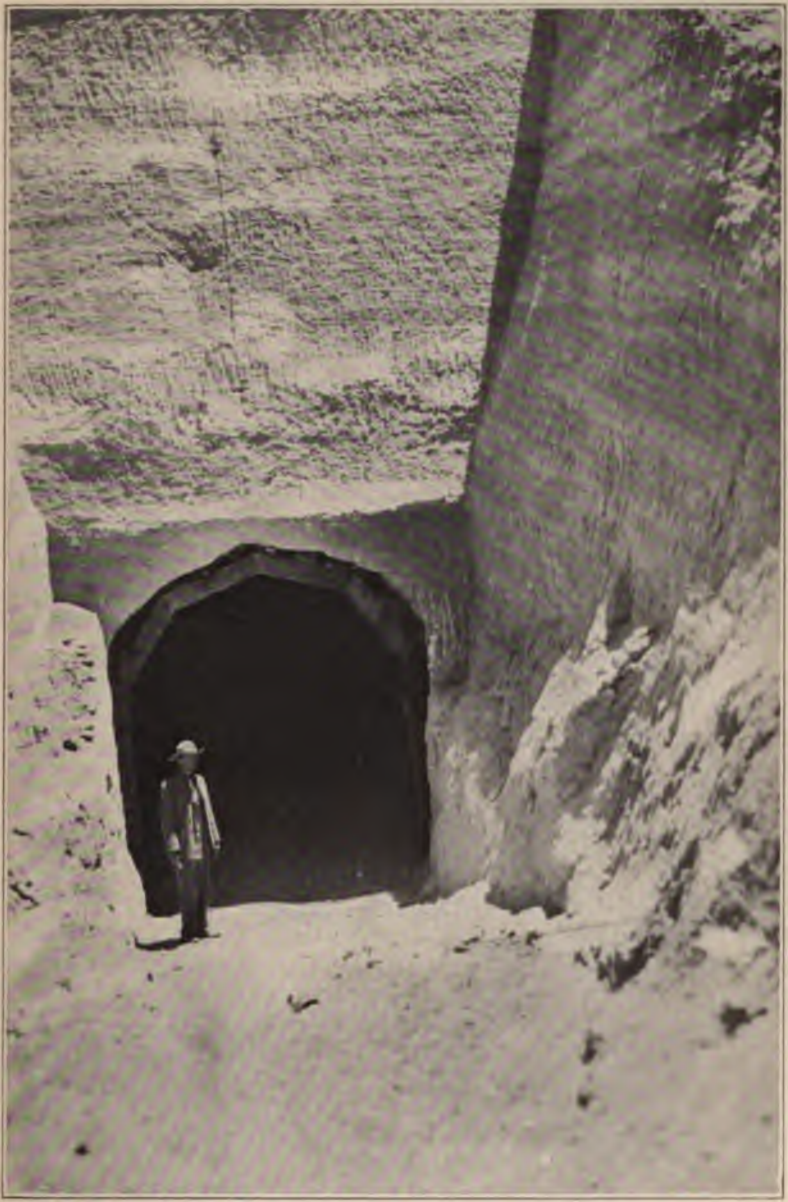
From Haiwee to Fairmont the main conduit will consist essentially of the following:

	Feet.
Canal, concrete lined	583,656
Tunnels, concrete lined	109,157
Inverted Steel Siphons	56,017
Steel and Reinforced Concrete Flumes	9,050
Total	757,880

From Fairmont to San Fernando the main conduit consists of the Elizabeth Tunnel, the length of which is 27,215 feet, and in Saugus Division the following:

Canal, concrete lined	15,289 lin. ft.
Tunnels, concrete lined	40,370 lin. ft.
Inverted Steel Siphons	18,830 lin. ft.

The various sections were designed in the Los Angeles office of the Aqueduct but the selection of type was determined by the locating engineers after careful study of the ground. The estimated cost for each type of conduit for varying conditions of topography and soil was determined by the Chief Engineer. Copies of these cost figures



SOUTH PORTAL OF TUNNEL NO. 18—JAWBONE DIVISION.

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were given to the locating engineers as a basis for an economic location. In addition to divisions of the main conduit type, as tunnels, canals, etc., further subdivisions were made of these sections into sizes. The capacity in all cases is 430 second feet and the relative size of each type is controlled by the gradient or fall it will have, so that considering the various factors involved, the economic location of the Aqueduct was a complex matter. The subject of selection of type will be discussed in greater details under "Surveys" and the question of gradients under the subject "Economic Gradients."

METHODS AND MATERIALS OF CONSTRUCTION.

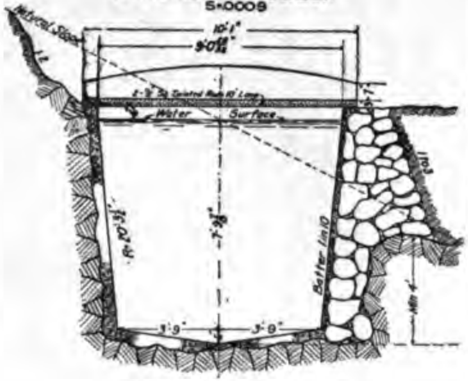
Lined Canal.

The bulk of the excavation for the lined canal will be with power shovels. This is especially true of the divisions known as the Rose Valley, Freeman, Section 1 of Jawbone, Mojave and Antelope. In Sections 2 and 3 of Jawbone and in the Grapevine Division the canal is located on steep, rocky hillside and is here termed rock bench conduit. (See Drawings 6 to 8 inclusive.) In the major portion of this work blasting must be employed and some of the loosened material below the water line of the canal may have to be removed by hand. The gravel and sand required for the concrete will, in most instances, be procurable from sources near the work. There are stretches of conduit however, several miles in length where concrete materials must be hauled a distance of three to five miles.

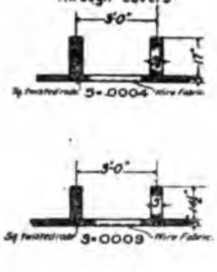
Tunnels.

All of the Aqueduct tunnels will be lined with concrete: the lining to vary in thickness from 6 inches to 14 inches. Timbering is employed only where necessary to protect the workmen against falling rock and in swelling or loose ground. It is impossible to predict the amount of this timber required. In illustration, the Elizabeth Tunnel which is being driven from both ends, requires timbering continuously at the north end, while the south end, bored 2508 feet, November 1, 1908, has required little timber. The rock at the south end is gneiss. The Aqueduct tunnels may be classified broadly as hard rock and soft rock tunnels. Most of the tunnels driven, so far, are rock tunnels. In order to keep well within the estimate of time for the completion of the Aqueduct, work on sections where tunnels of the hard rock classification are found, is being started as soon as the preliminary construction will permit, as progress in this material is necessarily slower. The shorter tunnels are being drilled or bored by hand, while the longer tunnels machine drills are used. These are

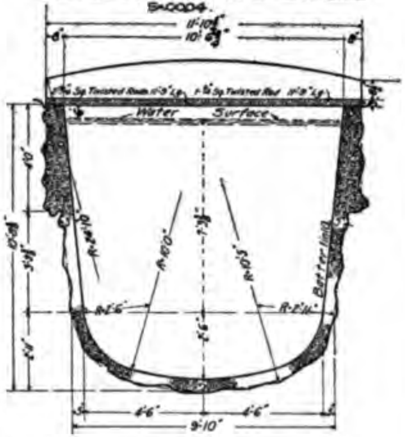
GRAPEVINE BENCH CONDUIT
S=0009



Longitudinal Section
Through Covers

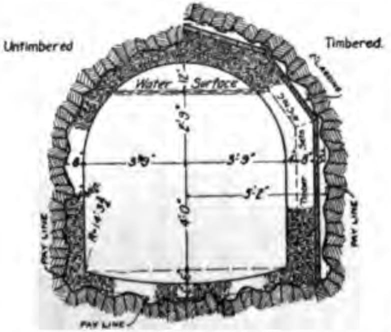


CONDUIT IN
ROSE VALLEY, FREEMAN & JAWBONE DIV'S.
S=.0004.



Untimbered

Timbered.



GRAPEVINE TUNNELS.
S=.002

HYDRAULIC PROPERTIES			
	Tunnel	Conduits.	
	S=.002	S=.0004	S=.0009
Capacity	433	430	429
Velocity.	6.48	4.825	6.45
Area.	51.10	88.16	66.64
Wetted Perimeter	21.70	26.00	23.27
Hydraulic Radius.	2.36	3.43	2.865
N	.014	.014	.014
C.	123.5	130	126.8

CONSTRUCTION QUANTITIES PER LINEAL FT. OF CONDUIT. NORMAL SECTION.

	Unit	S=.0009	S=.0004
Concrete in Conduit.	Cu. Yds.	0.4603	0.561
Concrete in Cover	Cu. Yds.	0.145	0.184
Steel in Cover	Lbs.	7.51	11.40

CONSTRUCTION QUANTITIES PER LINEAL FT. OF TUNNEL S=.002 NORMAL SECTION

	Unit	Timbered	Untimbered
Excavation	Cu. Yds.	3.57	2.705
Concrete Lining	Cu. Yds.	0.907	0.684
Timbering.	B.M.	81	

CITY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
LOS ANGELES AQUEDUCT

STANDARD TUNNEL AND CONDUIT SECTIONS
FOR
ROSE VALLEY, GRAPEVINE AND FREEMAN DIVISIONS.

SCALE IN FEET

DRAWING NO. 6.

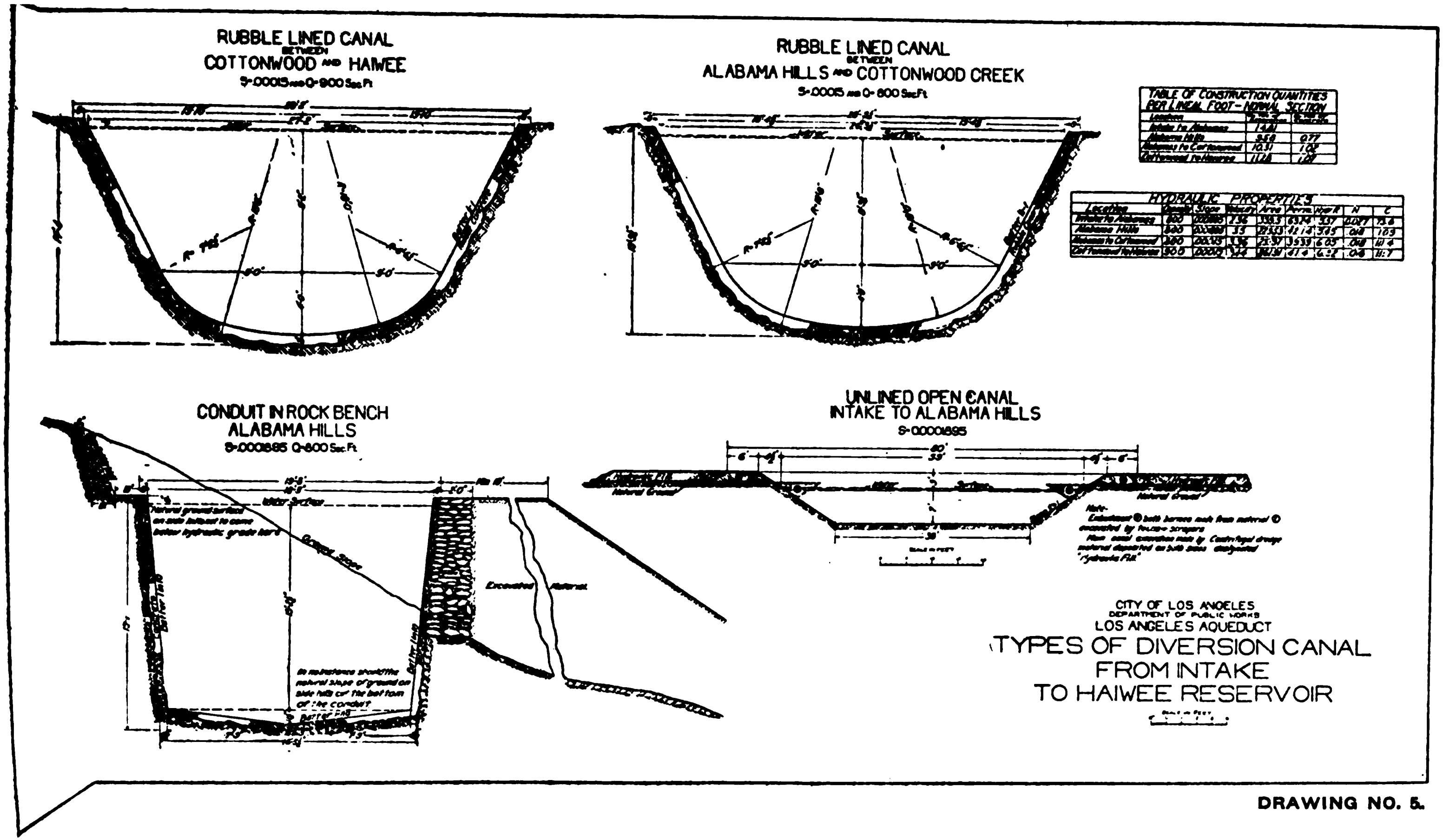

RUBBLE LINED CANAL BETWEEN COTTONWOOD AND HAIWEE
S-.00015 AND Q-900 Sec. Ft.
RUBBLE LINED CANAL BETWEEN ALABAMA HILLS AND COTTONWOOD CREEK
S-.00015 AND Q-600 Sec. Ft.
CONDUIT IN ROCK BENCH ALABAMA HILLS
S-.001895 Q-600 Sec. Ft.
UNLINED OPEN CANAL INTAKE TO ALABAMA HILLS
S-.0001895
Water Surface
Grade Slope
Batter 1 in 10
Excavated Material
Hydraulic Fill
Natural Ground
Scale in Feet
80'
33'
6'
38'

TABLE OF CONSTRUCTION QUANTITIES PER LINEAL FOOT—NORMAL SECTION

Location	[illegible]	[illegible]
Intake to Alabama	14.41	
Alabama Hills	3.58	0.77
Alabama to Cottonwood	10.31	1.02
Cottonwood to Haiwee	11.26	1.01

HYDRAULIC PROPERTIES

Location	Capacity	Slope	Velocity	Area	Perim.	Hyd. R	N	C
Intake to Alabama	600	.0001895	2.56	353.3	65.74	5.37	.0027	73.6
Alabama Hills	600	.001895	3.5	171.53	42.14	3.95	.018	109
Alabama to Cottonwood	600	.00015	1.56	253.37	35.35	6.05	.018	101.4
Cottonwood to Haiwee	900	.00015	[illegible]	[illegible]	41.4	6.2	.018	111.7

Note—
Embankment ① both berms made from material ② excavated by Fresno scrapers.
Main canal excavation made by Centrifugal dredge material deposited on both sides designated "Hydraulic Fill"

In no instance should the natural slope of ground on side hill cut the bottom of the conduit

CITY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
LOS ANGELES AQUEDUCT
TYPES OF DIVERSION CANAL
FROM INTAKE
TO HAIWEE RESERVOIR

DRAWING NO. 5.

operated by compressed air and require an expensive plant, hence they are economical only in long tunnels. A discussion of the equipment of the Elizabeth and other tunnels will be found in a description of the work being done in the separate divisions.

Six tunnel plants quite similar to those of the Elizabeth Tunnel have been constructed in Sections 2 and 3 of the Jawbone Division. Three tunnel plants will be required in the Grapevine Division and four in the Saugus Division. The electrical energy required for the tunnel plants in Grapevine and Jawbone Divisions will be supplied from the City's own power plants. These power plants of almost 3,000 H. P. will furnish motive power for three hydraulic dredges and numerous power shovels in addition to supplying the tunnel plants. Descriptions of these power houses and transmission equipment will be found in the report of Mr. E. F. Scattergood, Consulting Electrical Engineer.

Siphons.

The siphons, so called, will be inverted, or U shaped pressure pipes which will carry the water across canyons or valleys. These are used only where they are more economical than it would be to build a canal following the contour around the depression. This latter distance is often from three to seven times as great as the length of the pipe. The siphons will be constructed of steel pipe fabricated from steel plates. The minimum thickness of the plates as designed will be one-fourth of an inch, while the maximum thickness will be determined by the hydraulic pressure. The maximum thickness of riveted pipe that can be fabricated economically is assumed to be one inch. In one instance, that of the Jawbone Canyon siphon, this requires reducing the pipe on the floor of the canyon to 7 feet in diameter, in order to keep the thickness within the prescribed maximum of one inch. Sufficient grade has been allotted to this siphon to enable the compounding of the pipe to be effected. For this pipe the diameter near the ends will be ten feet and will change by gradual steps to nine, eight and seven feet. The Jawbone siphon will have the highest pressure of any siphon on the Aqueduct and is the most expensive type of main conduit construction per foot with the possible one exception of the Elizabeth Tunnel. The total length of pipe in the Jawbone Siphon is 8365 feet. The estimated cost is about $335,000, or an average of $40.00 per lineal foot. The total length of siphons on the Aqueduct will be about 74,847 lineal feet. The estimated weight of steel required is 18,150 tons. While an enormous quantity of steel is required for all the siphons, the length of time it will take to construct them is relatively short: thus no one siphon will require more than eighteen months' time to construct and the majority can be built in less than three months. In order to avoid unnecessary interest on bonds, the construction of the siphons is being left until the last two years of construction.

Flumes.

The flumes of the Aqueduct are located over shallow depressions where the maximum depth is not more than 30 to 40 feet. Most of the flumes will be fabricated from steel in the shape of rolled plates and angle bars, so riveted together as to form an effective canal section and at the same time the sides act as a plate girder bridge to support the weight. Flumes will also be constructed of reinforced concrete instead of steel where the cost of forms in not excessive. This is the case in narrow canyons between portals of two successive tunnels. The tunnel dump will fill up the canyon to within a few feet of the bottom of the flume and thus eliminate the necessity of expensive centering.

SURVEYS.

Approximately 800 miles of alternate lines have been surveyed by the field parties of the Aqueduct. In the preliminary survey, angle lines are run, which serve as a base to develop the topography of a strip of country on either side thereof. The country as finally developed by all the surveys, embraces an average vertical distance of 200 feet for the entire length of the Aqueduct, the horizontal distance varying with the slope of the ground. Several trial routes were projected upon the topographical maps and run out in the field, then estimated upon. The modifications have been made only in the route from Haiwee Reservoir south. The first line surveyed was a high line from Haiwee to Little Lake, then dropping to the floor of the Valley with the idea of utilizing this drop for power development. From Little Lake to Indian Wells the line followed the Valley floor, which necessitated the use of a great length of steel pressure pipe as inverted siphon. From Indian Wells south, the line proceeded to Antelope Valley, practically paralleling the later routes, but at a much lower grade and crossed the Antelope Valley by means of 11 miles of pressure pipe, whereas the distance around in grade was three times as great. From the end of this siphon, the route proceeded southeasterly to Palmdale, thence southerly by a series of tunnels under the Sierra Madre Mountains, passing Acton on the Southern Pacific Railroad and finally entering the Big Tehunga Canyon, whence it reached the San Fernando Valley. The field studies and estimates led to material changes in this route.

First: The substitution of a high grade tunnel and conduit line was made for the siphon line following the Valley from Little Lake to Indian Wells, using somewhat more than 100 feet of fall for that purpose, thereby reducing the size and cost and increasing the permanence of construction.

Second: The elevation of the entire line from Indian Wells to the Fairmont Reservoir was raised approximately 60 feet at the lower end, and 110 feet at the upper end, which makes the most of a further amount of the available fall and permits of the utilization of the Fairmont Reservoir.

Third: The proposed long siphon across Antelope Valley has been eliminated and a conduit line, further west and crossing the Valley with a siphon 4½ miles long, will be built. This increases the length of the Aqueduct, but effects a saving in head at Fairmont Reservoir.

Fourth: A direct line via San Francisquito Canyon has been substituted for the long detour via Palmdale and Acton—thus saving 20 miles in distance including one five mile tunnel.

Surveys were made, based on these revised grades. A detailed grade study of the line between Haiwee and Fairmont was then made by Mr. J. B. Lippincott, Asst. Chief Engineer, and Mr. E. A. Bayley, Asst. Engineer. Practically the total fall between Haiwee and Fairmont was utilized but the distribution of this fall among the different types of conduit was considerably changed. By adopting the various gradients arrived at in this study, an apparent saving was made of $568,000. Another survey was made on these changed grades and the Aqueduct route was definitely located.

It is upon the routes and grades of this final definite location that the Aqueduct construction has been commenced. From the San Francisquito Canyon to the San Fernando Reservoir three routes were surveyed, these being practically identical in cost. The final location was determined by costs of obtaining right-of-way rather than by construction costs. The aggregate length of the Aqueduct over the line fixed by the grades established by the Consulting Board of Engineers was as follows:

	Feet.	Miles.
Unlined Canal	117,200	22.20
Lined Canal	868,700	164.53
Tunnels in Rock	96,295	18.24

Tunnels in Earth	53,370	10.11
Siphons Crossing Canyons	47,460	8.99
Flumes Crossing Shallow Depressions	9,500	1.80
Total	1,192,535	225.87

The aggregate length of the Aqueduct by the final location is as follows:

	Feet.	Miles.
Unlined Canal	111,200	21.08
Lined Canal	803,711	152.25
Tunnels in Rock	91,019	17.24
Tunnels in Earth	58,508	11.08
Siphons Crossing Canyon	74,847	14.19
Flumes	9,050	1.72
Total	1,148,335	217.56

The final line thus shows a shortened distance of 44,200 feet compared with the length of the line established by Board of Engineers, distributed as follows:

	Feet.
Canal	70,989
Tunnels	138
Flumes	460
Total	71,587
Increased length of Siphons	27,387
Resultant saving in Distance	44,200

The results of all these studies and surveys have been to improve and cheapen the line.

Reservoir Surveys.

The surveys for each reservoir consisted of a topographic survey to obtain data for making a topographic map, a detailed topographic survey of the dam site and a boundary survey of the proposed water line for Right-of-Way purposes.

Economic Gradients.

The controlling elevations of the Aqueduct are: 1. Black Rock Springs fixing the Intake in the Owens River at an elevation of 3814.8 in order that the valuable waters of the Spring may be diverted into the conduit. 2. Haiwee Reservoir at an elevation of 3760 to insure sufficient capacity for seasonal flood regulation. 3. Fairmont Reservoir at an elevation of 3035. 4. San Fernando Reservoirs at the southerly extremity of the Aqueduct. A grade elevation of 3545 at the gateway below Haiwee Reservoir may also be said to be fixed. There is thus an available fall of 54.8 feet for the 60 miles of Diversion Conduit or an average gradient of 0.91 feet per mile and 0.173 feet per thousand. This is necessarily a flat gradient and is rigidly fixed by nature. The gradients as adopted were one foot per mile from the Intake to the south end of the Alabamas and 0.15 feet per thousand for the remaining distance.

Haiwee to Fairmont.

From the gateway below Haiwee to the water surface of Fairmont Reservoir, the total available drop is 510 feet in a distance of 143.5 miles, an average gradient of 3.56 feet per mile. As the Aqueduct passes through all kinds of country and includes various types of conduits it is evident that it would not be good engineering to use the same gradient for the entire length. There is evidently some distribution of gradients required for the different types of conduits and the various kinds of material encountered, which will make the combined cost for the total distance a minimum. The object of the detail grade study was to determine the most economical possible distribution of this fall. Drawing No. 11 contains a graphical sumamry of the economic grade study and a mathematical proof of the theory upon which the study was based. The Aqueduct between Haiwee and Fairmont consists essentially of lined canal in earth in Rose Valley Division; hard rock tunnels, covered and lined canal in rock bench, and steel siphons in Grapevine Division; lined canal in Freeman or Dixie Division; earth, soft rock and hard rock tunnels, siphon and canals in Jawbone Division, etc., etc. For each of these types in each division of county, unit construction costs were estimated for various grades. It is evident that the steeper the grade, the smaller and hence cheaper, the conduit section. The assumed slopes, multiplied by the total strength of each section gives the total head, or fall, while the unit cost multiplied by the length gives the total cost. These data were then platted as curves, not shown in this report. They are designated as gross cost curves. The more head that is consumed in any gradient for any given section, the higher in elevation the portion of the line north thereof must be located. Where these northerly portions of the line are situated on steep side hills, there will be a corresponding increase in the construction cost, due to the increased cost of hoisting materials. From experience gained elsewhere, this cost of hoisting

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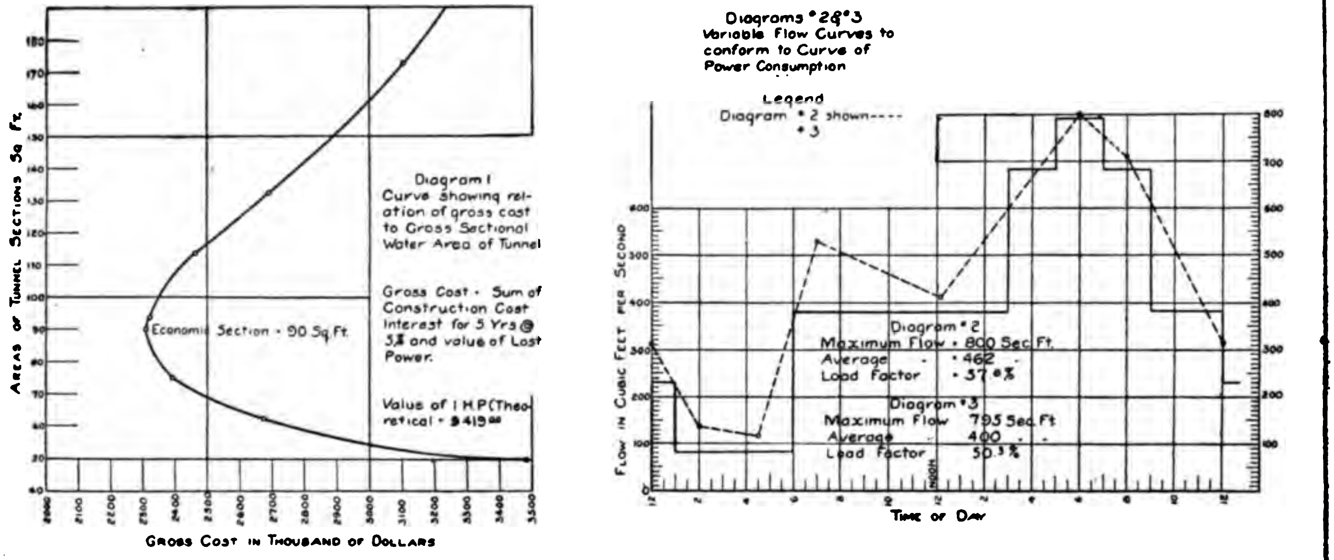
is estimated at one cent per cubic yard of concrete per foot of lift. In addition, a raise in grade elevation may increase the pressure head on all siphons above the portion of the line in question. On the small diagrams, this charge for raising the line is added to the "Gross Cost Curve," giving a "Net Cost Curve" showing the relation between total head and total cost for each section of the Aqueduct considered. The Net and Gross Curves coincide at a point corresponding to the gradient recommended for the section in question by the Board of Consulting Engineers. On the diagram which is shown as Drawing 11 of this Report, the Net Cost Curves are platted to the same scale. The most economic distribution of the available head was determined from the original of that diagram. The tabulated results are shown on Drawing No. 11.

Elizabeth Tunnel.

A study was also made to determine the economic cross sectional area of the Elizabeth Tunnel. This tunnel will form a part of the power pressure conduit directly connecting Fairmont Reservoir with the first San Francisquito power-plant. If the cross sectional area of this conduit is increased, the slope required to maintain any given velocity is decreased with a greater net drop available for the development of electrical energy.

In the Chief Engineer's First Annual Report, (March, 1907), Appendix J., Mr. E. F. Scattergood, Consulting Engineer, estimates the net annual income from each horse power developed at $38.00. The assumed efficiency of the combined system, including losses in pipe lines, water wheels, generators and transmission lines was 55.2%. Hence each theoretical horse power developed will deliver actually only 0.552 horse power, or the value of each theoretical horse power is $38.00x55.2% or $20.96. Capitalizing $20.96 at 5% gives $419.20 as the asset of the City for each theoretical horse power. Every foot of head required in the tunnel reduces correspondingly the available power drop in San Francisquito Canyon and hence represents a direct loss in power output which can be determined for any assumed rate of flow. Every horse power so lost represents a lost asset to the City of $419.20. Evidently then, in estimating the cost of the tunnel the loss in capital to the City, which is represented by actual construction cost plus value of "lost power" should be considered. Taken purely as a power proposition, the power drop will not be revenue producing until the power houses are constructed and operated. This may not be until several years after the tunnel has been completed. Hence in this study, interest on the estimated construction cost was added at the rate of 5% for five years. The sum of construction cost, plus



DIAGRAMS

ILLUSTRATING

ECONOMIC GRADE STUDIES

ELIZABETH TUNNEL

JULY 1907

DRAWING NO. 12.

interest for five years and the value of the power were added, and tabulated as "Gross Cost." [illegible] Drawing [illegible] shows the variation of gross cost with the area of the tunnel cross-section. The economic area is found to be 9 square feet.

Saugus Division.

Studies similar to that of the Elizabeth Tunnel were made for the various tunnels, siphons and canals in Saugus Division. The power value here was considerably reduced on account of its necessarily being a uniform output and not subject to regulation for peak loads. The unit power value was assumed equal to [illegible] of the unit power developed in the San Francisquito Canyon. The possibilities of future power development, however, have been carefully conserved in designing the aqueduct. The subject of "Power" in the Saugus Division is discussed at greater length in the Progress Report on the Saugus Division, page [illegible]

FORECAST OF CONSTRUCTION PROGRESS AND ESTIMATE OF COST, FOR THE COMING YEAR.

Owen Valley Division (No. 2).

It is intended that work shall be carried to completion on Division Creek Power Plant No. 2. The estimate of cost of same is $[illegible] The penstock pipe for this plant is now about one-half laid, and the buildings are nearly completed. None of the machinery has yet arrived, but it is expected that the machinery will be set and the plant in shape for operation by about the middle of January. It is designed that this plant shall furnish power for Dredge No. 2, the construction of which is now under contract. All the power developed by this plant in excess of that required by Dredge No. 2 will be coupled up with the Cottonwood Plant and used for construction work where required. Its normal capacity will be 750 H. P., but by the use of a small surge tank it will be able to carry 30% excess load for a period of six hours.

Power Plant No. 1 has been in operation since April last, furnishing power to operate Dredge No. 1. Work on the canal was begun with this dredge on May 1st, 1908, and has progressed in a desultory way up to the present time. The machinery as at first designed was more or less experimental, and while the design was found to be effective on most of it, defects developed in the cutters and a few of the minor parts, involving frequent stoppage, and owing to the great distance from repair shops, serious and expensive delay

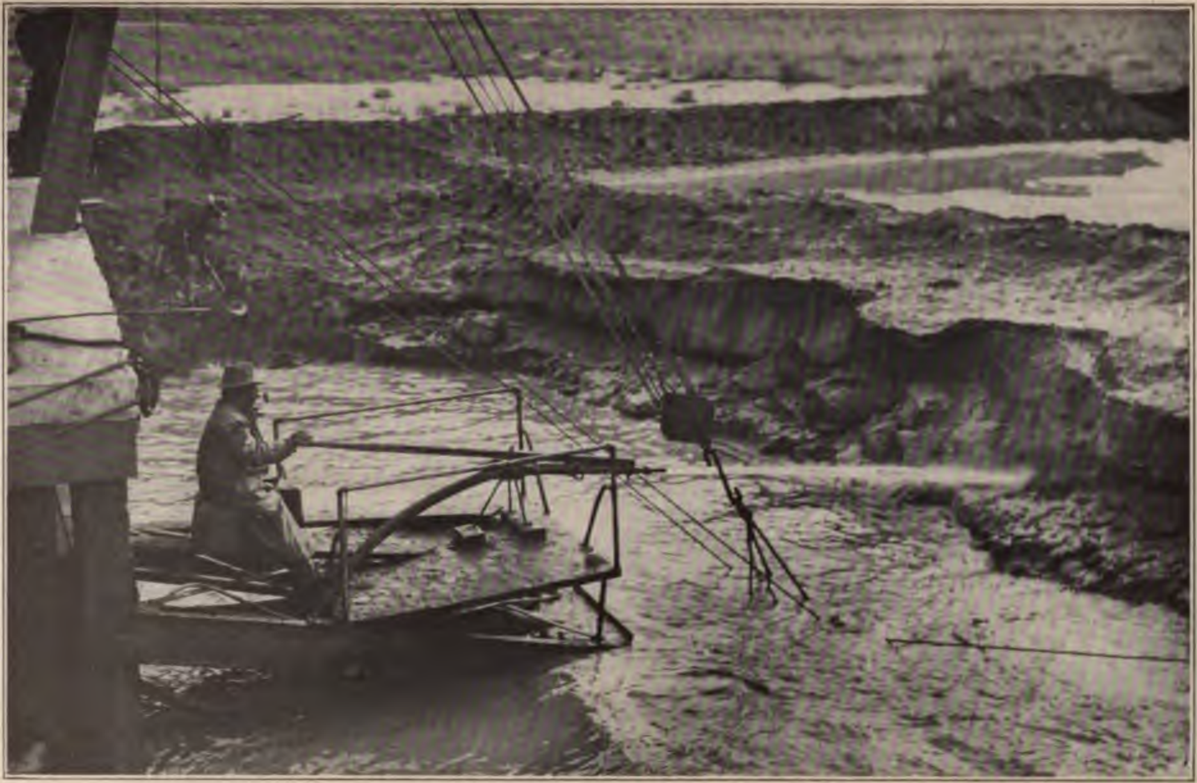
Up to date, about 4,000 feet of canal have been excavated, the progress of the last two months accounting for more than one-half of it, due to the fact that the difficulties spoken of are being rapidly overcome. Dredge No. 2 was designed, having in mind all the defects in No. 1, and will no doubt from the first prove an efficient and economical machine.

It was originally intended that this portion of the Aqueduct should have a capacity of 700 second feet. After the work was begun, it was found fully as economical to dig this canal of larger section than originally intended, which has the effect of lowering the high water flow line in the canal, and keeping the wetted section deeper down in the saturated soil of the valley. This change will result not only in a saving of loss by seepage from the ditch, but an actual accretion of water that in all probability will amount to more than 25 second feet in the first twenty miles of canal. This added quantity of water will of course be more available during periods of low flow than in the periods of high water, which is a manifest advantage. A larger portion of the stream flood flow may be diverted by thus increasing the capacity of the main canal.

Dredge No. 1 was started at Station 198+50, which is near the channel draining Black Rock Springs. The water from these springs was used to float the dredge and give water for the excavating operations. The work is progressing southerly from this point. Dredge No. 2 will be started at about Station 750, which is immediately south of Citrus Road, and will work southerly from that point.

A well has been bored which affords a water supply for floating and operating this dredge. This well has been sunk to a depth of 325 feet through fine sand and gravel, with a few thin beds of clay, the material penetrated being water-bearing from within a few feet of the surface clear to the bottom of the well. It was too fine, however, to perforate very coarsely, and hence the free flow it would otherwise give was cut down materially. The amount flowing, however, is 1½ second feet, and by the use of an air compressor which it is intended to install at this point, the well will probably yield four to five second feet, which will be sufficient for the purposes of the dredge by the time the excavation has advanced a few hundred feet.

It is intended to operate this dredge both night and day during the summer months. This is somewhat impractical during the winter on account of the cold produced by the spraying effect of the cutting nozzle, making night work ardous and disagreeable. It is expected that a progress of five miles or over will be made on this portion of the Aqueduct during the coming year.



HYDRAULIC SUCTION DREDGE AT WORK IN OWENS VALLEY.

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I would advise, inasmuch as there are eleven or twelve miles of heavy work along the face of the Alabama Hills, that a high power shovel be placed there at the earliest time railroad facilities will permit. From promises of the railway people, it is safe to assume that this will not be later than June 1st. A construction gang will follow this shovel, building and completing the conduit as it goes. A fair estimate of the rate of progress on this work would be an average of fifty feet a day. Even with this rate of progress, this particular section of the work would require about four years for its completion. It is possible, however, to work at night at least during the summer season on excavation work. The concrete work can easily be executed to keep up with any rate of progress of the shovel, and should it be found necessary towards the expiration of the time for the completion of the Aqueduct, another shovel can be put to work there.

Olancha Division (No. 3).

Work should be begun at the earliest possible date, which will be about April 1st, on the excavation of the conduit from the upper end of the Haiwee Reservoir, working northerly. The distance from this point to the southerly end of the Alabama Hills is fifteen miles. While a great deal of this distance is through easy excavation, there are a few miles of it crossing the boulder fans of Olancha, Ortega, Walker, Ash and Cottonwood Creeks, where the digging will be somewhat difficult. Progress on this section can scarcely be expected to exceed an average of seventy feet a day. As the distance is about fifteen miles, it will probably be necessary to accelerate the speed of this work as in the case of the shovel work in the Alabama Hills, by night work or otherwise, towards the completion of the Aqueduct.

Construction work on the Haiwee Reservoir should begin during the coming spring. It is expected that the railroad will be completed to this point by March 1st, at which time the equipment for this work can be delivered. As it is intended to build the dam by the hydraulic process, the equipment will consist of a power shovel of large capacity, a two-stage centrifugal pump of about 300 inches capacity against a head of 150 feet, and all the necessary piping and sluice boxes. Water is now being accumulated in a depression just above the dam site of this reservoir, the supply being drawn from Haiwee Creek. It is hoped that a sufficient amount of water will have accumulated by the time stated. It would be useless to begin this work until a supply in excess of fifty acre feet is stored for use, after which it is expected that the flow of Haiwee Creek will more than compensate for all the losses of operation.

The power shovel is necessary on this work for the reason that the earth which it is designed to use in the dam contains many boulders that would render jetting ineffective, as the boulders would drop from the face of the bank being operated on, and require removal so that the jet might work effectively. It is proposed therefore, to work directly from the face of the cut with the shovel, dumping the earth on a grizzly straddling the sluice boxes. As the dam contains 530,000 cubic yards of material, and the expected progress is at the rate of 2,000 yards a day, one year from the commencement of the work should be a sufficient time for its completion.

Plans are not yet prepared for the gate-house and its equipment, and hence no estimate can at this time be given as to its cost. As the outlet from the reservoir will be through a tunnel, the work on the gate-house and this tunnel need have no reference in point of time to the construction of the dam, and no provision need be made for it during the coming year.

It has not yet been decided what method will be adopted in the building of the small dam at the head of the Haiwee Reservoir, and its construction, in any event, will not be required during the next year.

Rose Valley Division (No. 4).

This division is about fifteen miles long. As most of it is easy work on which a progress of 100 feet a day may be expected, the commencement of the work can be deferred for at least a year, mainly for the reason that we will have to economize in power, and await the release of some of the power being used in the Jawbone Division.

Grapevine Division (No. 5).

This being a rough and expensive division containing many tunnels in hard rock, it is deemed prudent to begin work on this at the earliest possible date. The railroad is now completed to Siding 17, in front of Grapevine Canyon, which is about the center of the division, so that transportation facilities are afforded for the commencement of the work. Road and trail building has been in progress on the rougher end of the section in the vicinity of Little Lake for nearly a year, and the driving of the tunnels can be begun before the first of January, 1909. It is intended to at once establish camps at four points in the Division, namely, at Soda Canyon, Five Mile Canyon, Nine Mile Canyon, and Grapevine Canyon. The minutiae of the final location is not yet complete, but this work will not delay the construction seriously. Ten headings in the long tunnels can be opene by March 1st, in which case a reasonable expectation of progress v be 8 feet a day for each, or an aggregate of 80 feet, which for the remaining nine months of the fiscal year would be about 21,000 feet. As there are about 28,347 feet of tunnels in the division, concreting in the shorter ones should be in progress by the end of the year.

For the open work on this division, two high power shovels should be purchased, one of which can be started at the Indian Wells siphon, working northerly, and the other at Grapevine Canyon, also working northerly. The rate of progress of these tools will probably not exceed 40 feet a day each, as the ground will require considerable blasting. As with all the cut and cover work, concreting can be carried on as the excavation is completed.

The bench conduits northerly from Sand Canyon will, with the probable exception of a short stretch between Nine Mile Canyon and Five Mile Canyon, be altogether hand work in hard rock, and the progress can be gaged by the rate required to finish the work in a reasonable time, having due consideration of the expediency of maintaining large or small camps, and also having reference to financial considerations. No prediction is made, therefore, of the yearly progress on this portion of the work.

The water supply for this division has not yet been developed. This work and that of its distribution will begin at once.

Freeman Division (No. 6).

This division is about 21 miles long, covering the route from Red Rock Summit to the Indian Wells siphon, and is altogether cut and cover work of easy character. It is recommended, inasmuch as the maintenance of the Red Rock spur railroad over which it is intended to convey the materials for most of this division is a precarious proposition, that this work should be begun this year and prosecuted with diligence in the southerly end, so as to make the period of time that this railroad spur will have to be maintained as short as possible. It is intended that a Model 40 Electrical Shovel shall be put to work by March 1st, starting from the southerly end of the division and working north. It is expected that the progress on this work can be maintained at the rate of about 2,000 feet per month, as that seems to be about the pace at which similar work in the Mojave Division is now being accomplished. The water supply problem for the southerly five or six miles of this division is already solved by the Sage Canyon pipe line.

Jawbone Division (No. 7).

This division is 21.9 miles long. Construction work was begun in September, 1908. The work so far, aside from the preparatory work of road building, power line construction and laying of pipe lines, has been mainly confined to tunnels, of which there is an aggregate of 43,650 feet in the division. At the present writing about 8,500 feet of tunneling has been completed, and it is expected that all of the tunnels with the exception of Nos. 35, 38, 39, 40, 42 and 43 will be completed in the next fiscal year. Concreting will be started as the driving of the shorter tunnels is finished, and the progress should be such as to accomplish the completion of the lining, with the exception of the tunnels named, within the year.

An electrical shovel is now on the ground and will begin work by January 1st, in Section 1 of the Division, in the cut and cover portion. There are 38,000 feet of this work, and a rate of progress of 60 feet a day may reasonably be expected. This would complete about 16,000 feet of the work by the end of the next fiscal year.

Mojave Division (No. 8).

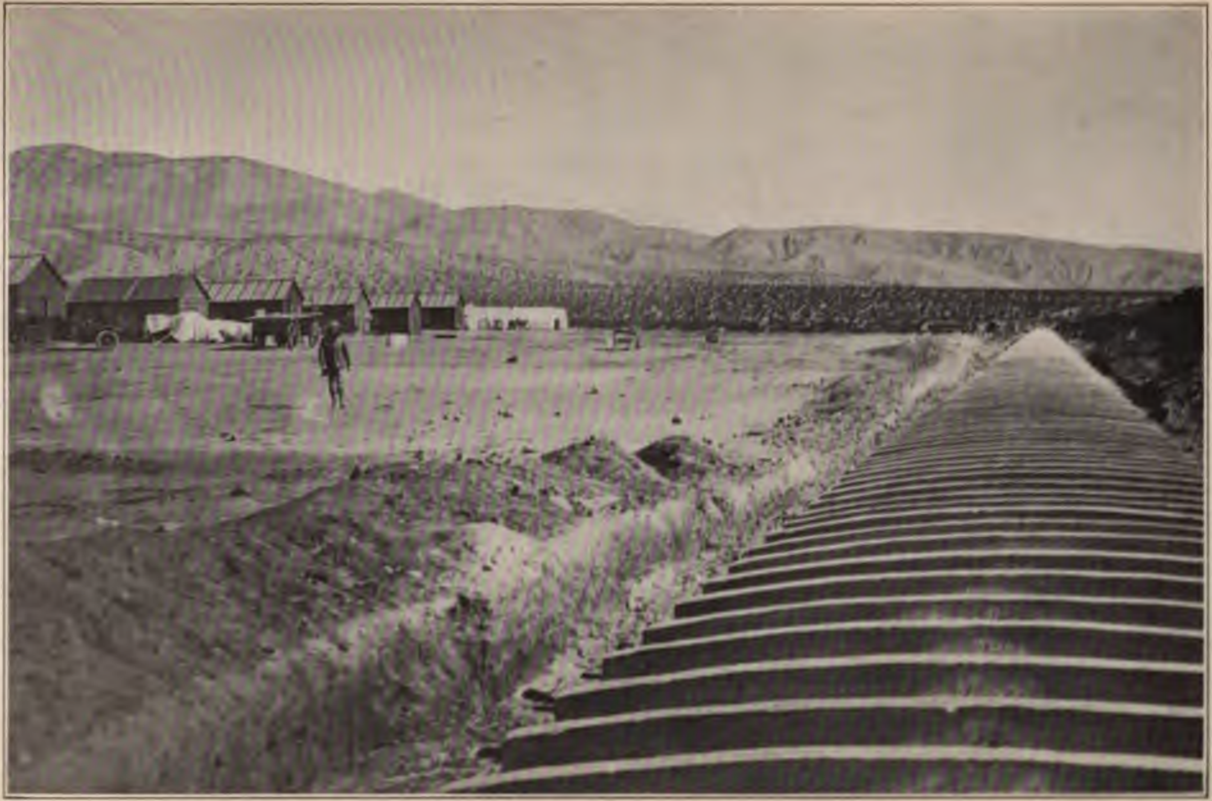
This division is 28 miles long. Work has been begun at a point where the Aqueduct intersects the Southern Pacific Railway, about four miles north of Mojave. Two steam shovels started at this point, one working northerly and the other southerly, both of them followed by concreting gangs. About 4,000 feet of conduit has been completed so far, and the rate of progress should be maintained at about 2,000 feet a month for each shovel.

An Austin Excavator is being erected about ten miles south of this point, which it is expected will be ready for operation about December 15th. This will make three gangs at work on the Mojave Division, and will enable us to complete an aggregate of 6,000 feet a month. At this rate it will require only about two years to complete the division, so that it will not be necessary to increase the force.

It was originally intended that this conduit should remain uncovered, but it was finally decided that the first mile should be covered with a view of determining the cost. As far as the work has progressed, indications are that the conduit complete with cover will not exceed the estimate placed on its cost by the Board of Consulting Engineers without cover. The estimate given hereafter is therefore based on a covered conduit.

Antelope Division (No. 9).

This division extends from the northern end of the Antelope Valley Cottonwood siphon to the Fairmont Reservoir, a distance of 26.7 miles. Work has already been begun on the southly end of this division, which consists of 11 miles lying southerly from the Antelope Valley siphon. This portion includes a few short tunnels,



SHOVEL CAMP NO. 2—MOJAVE DIVISION, SHOWING COVERED CONDUIT.

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the balance being comparatively easy cut and cover work. A shovel has been ordered for this, which it is expected to have in operation by the first of February, provided the work has not been let by contract under the specifications now being advertised for bids. It is not intended that any other work shall be done on this division during the coming year.

A water supply from Kings' Canyon has been provided for this work, the pipe line now completed practically paralleling its whole length.

Elizabeth Division (No. 10).

The Elizabeth Lake Tunnel, which is the most prominent feature of this division, is being driven with unabated vigor, the progress at the present time being at the rate of about 600 feet a month. It is expected, however, that this will be somewhat increased by the additional two headings reached by a shaft located 3,000 feet from the North Portal. 1446 feet of tunnel have been driven from the north end, and about 2,900 feet from the south end.

The proposed Fairmont Reservoir is in this division. Work of stripping for the dam is already begun, and the building of the dam itself will be started early in the year provided a sufficient amount of water for sluicing operations can be accumulated. The dam will have a concrete core which will be carried up from bed rock 55 feet into the heart of the dam. Otherwise, the dam will be of earth built by the sluicing process. The dam will contain 723,862 cubic yards of earth,—this earth of fine quality and in unlimited quantity lying closely adjacent. The equipment required will consist of a high pressure two-stage turbine jet pump, capable of delivering approximately 110 miner's inches under 100 pounds to the square inch pressure, through a 2-inch Giant nozzle,—one low pressure single stage centrifugal pump with a capacity of 300 inches, to deliver the sluicing water, and the necessary piping and steel sluice boxes.

A rate of speed of about 2,000 cubic yards per day can be attained on this work, but as before stated, its inauguration will depend on the time at which water will become available. For the purpose of completing the estimate, it will be assumed that work can be begun about March 1st.

Saugus Division (No. 11).

This is topographically a very rough division, covering a distance of 14.4 miles, from a point in the San Francisquito Canyon to the south portal of the Newhall Tunnel. Two working camps have been established in this division, as well as main headquarters at Saugus Junction on the Southern Pacific Railroad. It is intended to vigorously prosecute work on this division during the coming year. It has not yet been determined whether this work will be done by the City's forces or let by contract, but for the purposes of this estimate, this is not material.

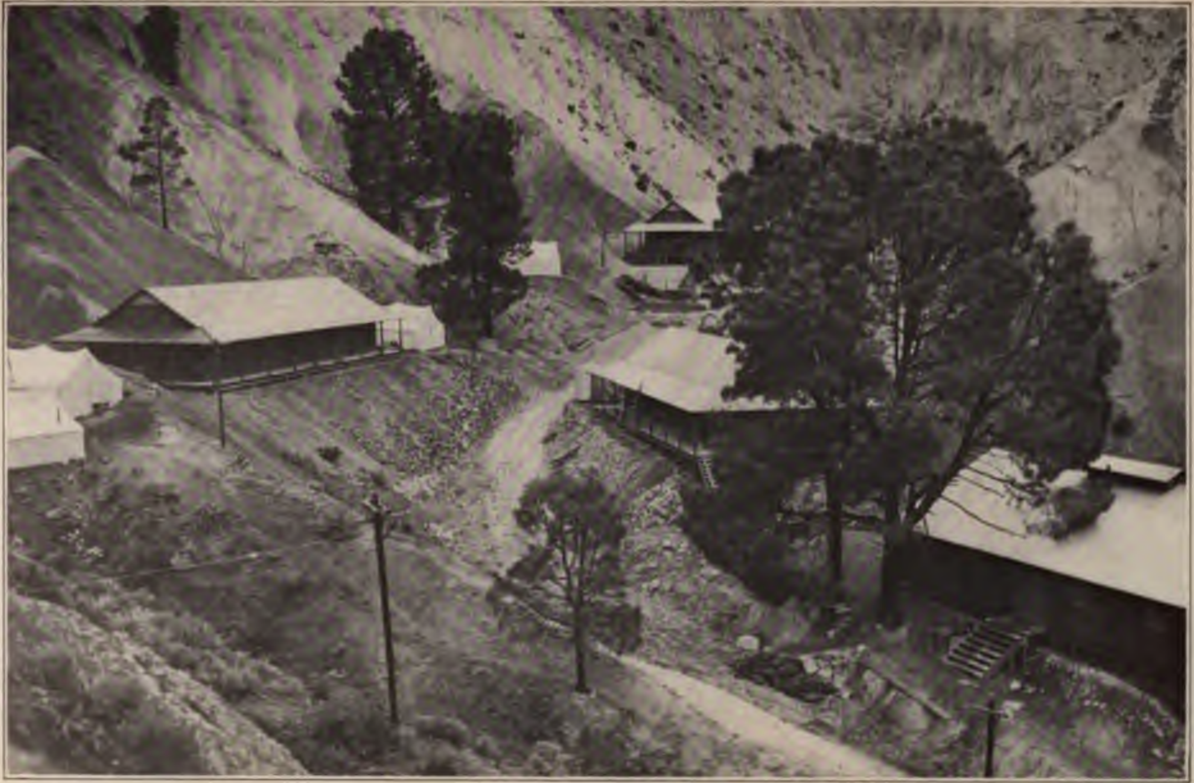
There are 30 tunnels in the division, aggregating 7.64 miles, mostly through a soft formation. All of these tunnels are comparatively short with the exception of Tunnel No. 103, which is 9,100 feet long. The rate of progress should average at least 6 feet per day at each heading, so that the short tunnels will be ready for concreting quite early in the year. Should our funds permit, work on this division could be expedited so that all of the tunnels but No. 103 could be completed and lined in a year and a half. For the purposes of this estimate, it will be assumed that 12 headings will be opened during the coming year, and that concreting will be carried on in them as fast as completed. It will not be necessary to do anything on the open work in this division for another year.

The problem of a water supply for this division is not a difficult one, and has already been solved in the northern end of the division by the sinking of surface wells. As the line crosses many canyons that are known to have water, it is expected that the water problem will be as easily solved at the southern end as it has already been at the northern end. Much of the equipment for the work is already on the ground in this division.

The folowing is a summary of the work which it is expected will be done during the coming fiscal year on the whole aqueduct, together with an approximate estimate of its costs.

Estimate of Construction to Be Accomplished on Los Angeles Aqueduct During Fiscal Year Ending Nov. 30, 1909.

DIVISIONS	TUNNEL EXCAVATED AND LINED Lineal feet	TUNNEL EXCAVATED Lineal feet	CONDUIT EXCAVATED AND LINED Lineal feet
Division 2.			
Dredges			25,500
Steam Shovel			7,800
Division 3			11,000
Division 5			
Tunnel	10,000	11,600	
Open Work			5,000
Division 6			16,000



AQUEDUCT CONSTRUCTION CAMP IN SUN CANYON.

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Division 7			
Tunnel	26,173	12,960	
Conduit	—	—	38,542
Division 8	—	—	72,000
Division 9	1,585	—	20,000
Division 10	—	7,200	
Division 11	21,900	4,380	
Total	59,658	36,140	195,842

Estimate of Money Required for Construction Operations During Fiscal Year Ending Nov. 30, 1909.

Division No. 2—Owens Valley	$ 264,700
Division No. 3—Olancha	204,850
Division No. 5—Grapevine	857,085
Division No. 6—Freeman	153,448
Division No. 7—Jawbone	1,153,362
Division No. 8—Mojave	551,000
Division No. 9—Antelope Valley	203,300
Division No. 10.—Elizabeth	358,300
Division No. 11—Saugus	537,920
Division No. 13—Cement Plant	143,654
Administration and Engineering	250,000
Owens Valley Ranches	6,000
Total	$4,683,619

The above program, embracing as it does, about 58 miles of Aqueduct, much of which is the most difficult work on the project, may seem rather a large undertaking for a single year, but reasoning from our present rate of progress on similar work, its accomplishment is quite possible.

The financial arrangements provide for $4,080,000 to be placed at the disposal of the Aqueduct during the fiscal year, and as there is at present on hand the sum of $559,585., clear of all our obligations, making a total of $4,639,585. available, it would seem to be the part of wisdom to apply it to the work rather than let it accumulate.

CLERICAL FORCES AND COST KEEPING.

The organization of the Engineering Department includes the clerical force connected with construction operations. The duties of this clerical force includes the assembling and recording of construction cost data; the keeping of all property records, showing the quantity and geographical location of all live-stock and non-expendable tools, machinery, and equipment owned by the Aqueduct Bureau; also, the work of time-keeping the distribution of labor and material charges, the preparation of pay rolls and all other clerical work arising in the field in connection with construction operations. Each camp is provided with a construction clerk whose duty it is to perform all work outlined above that may arise in his section or division of the work. All employees engaged in time-keeping or whose duties require them to issue time vouchers, or approve pay-rools, are required to furnish bonds.

Cost Data.

Since the beginning of actual construction operations, considerable attention has been given to cost analysis of work. In establishing a system of cost-keeping, an effort has been made to secure one that would give accurate results promptly. With this in view, it has been thought best to have the work of assembling the cost data performed in the field offices, and as near as possible to the point where the work is in progress. This enables the clerks to whom the work is assigned to acquire a personal knowledge of the work in progress, and to render their reports with far more intelligence than would be possible if they were not on the scene of the work. The cost reports that are being furnished at the present time consist of a "Ten Day Cost and Progress Report" and a "Monthly Cost and Progress Report" which are similar as to form. As the title of the former report would indicate, it is rendered at the close of the tenth, twentieth and last days of each month. Engineers are expected to forward their report promptly at the close of each period; and in the interests of promptness, they are permitted to sacrifice a certain amount of accuracy; but the monthly report, which is a summary of the ten-day reports, must be prepared accurately. One of each of these reports is required for each Engineer's Work Order upon which work is being prosecuted. These reports are transmitted by the engineer in immediate charge of the work to the Chief Engineer through the office of the Division Engineer. They are filed for reference in the Chief Engineer's Office; and upon the completion of the Engineer's Work Order, a detailed statement of the cost is prepared and furnished to all engineers interested. At the end of each month a Total Monthly Cost and Progress Report is prepared in the office of the Chief Engineer and forwarded to the Board of Punblic Works, showing the total cost and progress of all Work Orders under construction during the month.

Property Accountability.

The Chief Engineer is responsible to the Board of Public Works for the proper care and use of all non-expendable property issued for construction purposes. It has, therefore, been necessary to establish a thorough system of property accounting, showing the quantity of all property of the various classes and kinds owned by the Aqueduct Bureau and the location of the same. Under this system each Foreman or Superintendent in immediate charge of the work is accountable to the Division Engineer for all property in his charge, and the Division Engineer is accountable to the Chief Engineer for all property on the Division. In the office of the Chief Engineer there is maintained a record of all property for which each Division Engineer is responsible. This record is based upon an inventory taken August 1st of this year. Property acquired by fabrication or purchase is added to the record every ten days and the responsible officers are relieved of property worn out or unfit for use through inspection which is made near the close of each quarter.

Pay Rolls.

All pay rolls carrying the services of persons engaged in construction work are prepared in the field at the close of each month. These pay rolls are forwarded to the Accounting Department for audit and payment. They are approved by the Chief Engineer, the Chairman of the Advisory Committee and the President of the Board of Public Works. Payment for all personal services is made by Disbursing Officers check which reaches the employees in the field about the 15th of the month following that in which service is rendered.

Material.

All material and supplies used in construction work are secured by requisition on the store department. This Department has established warehouses at various points adjacent to the work, where all classes of materials and supplies are carried in stock. The Engineering Department is accountable for all material and supplies as soon as issued by the Store Department. A record is kept each day of all material and supplies used, and a report made to the Accounting Department at the close of the month, showing the Work Order number and classification upon which the material has been expended. The Engineering Department is thus relieved of further accountability in the matter.

Authority for Work.

Before any new piece of construction work may be undertaken, authority for the necessary expenditure must be obtained from the Board of Public Works. An engineering estimate is prepared showing the nature of the work to be performed and the estimated cost thereof, and this is presented to the Advisory Committee in the form of a recommendation from the Chief Engineer. After careful consideration by the Advisory Committee the recommendation is forwarded to the Board of Public Works for approval.

Work Orders.

After the Chief Engineer's recommendation for construction work has been approved by the Board of Public Works, Chief Engineer's Work Orders are issued which consist of a formal instruction to Assistant Engineers and Superintendents to proceed with the work. These work orders give a description of the work to be performed; also classification and unit and total estimated cost of same. These Work Orders are given numbers which are used by clerks and time keepers in indication of the distribution of labor and material expended thereon. The Chief Engineer's Work Order is the basis of all field accounting.

Purchases.

All purchases of material and supplies for use in construction work are made by the Store Department and on competitive proposals. Purchases involving five hundred dollars or less are made on informal proposals, but all purchases involving an expenditure in excess of that sum are advertised in the official journal of the City of Los Angeles; and proposals are received and opened, and awards made by the Board of Public Works. Provision has been made by the City Council, under the Emergency Clause of the City Charter, for emergency purchases which permit the officers of the Aqueduct to make small purchases without calling for competitive bids, but this is resorted to rarely and only in cases of real emergency. A detailed account of the work of the Store Department is to be found elsewhere in this report.

HOUSINGS.

The housing of the army of men engaged in the construction of the Aqueduct has been quite a problem. The buildings required include lodgings, dwellings, offices, mess houses, hospitals, warehouses and miscellaneous structures, as blacksmith and machine shops, tunnel plants, hay barns and stables. The total expenditure for such buildings November 1st was approximately $121,000. The floor space of these buildings is 175,000 square feet. The average cost per square foot for all the buildings constructed is 69 cents.

Lodgings.

The climate along by the Aqueduct varies from the intense summer heat of the desert when the thermometer reaches 110 degrees to a temperature of 10 degrees and 20 degrees above zero in winter. The effort was made to make the lodgings comfortable in both summer and winter as far as consistent with proper economy. The bunk houses for the laborers are made to accommodate two men to the room. Each room has an outside window. The cost of these buildings is about $25 for each man housed. Four room dwellings are erected for the Division Engineers who pay a monthly rent to the City sufficient to return the investment. These dwellings each cost from $600 to $900, depending upon the location and the cost of hauling the material. A building which will cost $600 in Los Angeles will cost $800 erected at South Portal or Grapevine on account of the long wagon haul.

Portable Houses.

Many of the Aqueduct buildings, such as offices, dwellings and bunk houses, are designed so that they may be taken down in sections, loaded on wagons and expeditiously erected again at some other point. These portable houses are being used on the Diversion Canal in the Owens Valley, and on the long stretch of light work in the Mojave Desert. There are many patented designs of portable houses, none of which fulfilled all the conditions required. The portable houses used by the Aqueduct were designed in the drafting office.

November 1st there had been constructed, exclusive of small outbuildings, 80 portable houses, 14 office buildings, 16 barns and stables, 16 ware and store houses, 33 mess houses, 5 bunk houses, 13 dwellings, 5 hospitals, 2 hydro-electric plants and 27 miscellaneous buildings.

CIVIL SERVICE.

The regulations of the Civil Service Commission governing the employment of persons in other departments of the City Government have been extended to cover the Aqueduct Bureau. A few positions, as laborer, carpenter, blacksmith, lineman, mechanic, etc., have, by official action of the Commission, been made exempt. The Commission has also made exempt a very few positions requiring expert technical knowledge, but with these few exceptions, all positions in the Aqueduct

Bureau are filled from the elegible lists of the Civil Service Commission. Examinations are being held at frequent intervals for the different classes of positions and elegible lists are maintained. An effort is being made to avoid as much as possible the filling of positions by emergency appointment. At the present time such appointments are made only in the clerical classifications and these exist because the requirement for clerks, time keepers and store keepers has been in excess of the number of persons passing examinations for these positions.

RIGHTS OF WAY.

Surveys and maps have been made showing the location of all reservoirs and canals and their connection with the land lines, extending from the Long Valley Reservoir site to the south end of the Fernando Tunnel, for obtaining rights of way over the public lands as well as over private property. They have been filed with the U. S. Land Office by the legal department, as required by the Act of Congress approved June 30, 1906. Descriptions of these rights of way will be found in the report of the legal department.

TRANSPORTATION.

The economical transportation of materials necessary for the construction of the Aqueduct, from a financial standpoint and next to the actual consideration of engineering difficulties, forms one of the most important factors of the undertaking. The Aqueduct, throughout the major portion of its length traverses the most arid part of Southern California. The country is sparsely settled and, until this time, has been unable to offer substantial inducements to common carriers.

The lower third of the Aqueduct, lying between the San Joaquin Valley line and Coast line of the Southern Pacific Railway, is capable of being served by a more or less extended wagon haul, which varies from an average of five miles on the Saugus Division to that of 25 miles on the south side of Antelope Valley. The remainder, from the crossing of the Aqueduct, four miles north of Mojave, to the intake in Owens Valley, a distance of 165 miles, has been regularly traversed only by a single tri-weekly stage line running from Mojave to Keller, the latter town being also the terminus of the N. & C. Railway, a narrow-gauge railway terminating at Mina, Nevada, and connecting, by means of a broad-gauge line, at that point with the main line of the Central Pacific at Hazen, Nevada.

Railroads.

It being apparent that methods other than ordinary wagon haul must be adopted for the conveyance and prompt delivery of material and supplies, estimates were made by the Engineers of the Los Angeles Aqueduct for both narrow and broad guage railroad lines, practically paralleling the proposed conduit location from the south side of Antelope Valley to within ten miles of the Intake on the Owens River, on the basis of hauling 287,500 tons of through and 1,500,000 tons of local freight, together with such traffic as might accrue from contiguous territory.

It was shown by these estimates, that, in the event of no satisfactory bids being received for the construction of such railroad, the Aqueduct could construct and maintain such a line, salvaging all track and operating material at the end of five years, and still reduce transportation charges from 25 cents, an average cost of desert haul, to less than 10 cents per ton mile. With this possible end in view, surveys were made from Antelope Valley to the proposed upper terminus in the Owens Valley.

California and Nevada Railway.

Advertisement for bids for the transportation of approximately 320,000 tons of freight from Mojave, north to various stated points adjacent to the proposed Aqueduct location, was made by the Board of Public Works, April 2nd, 1908. The accompanying specifications provided for the construction and operation of a standard guage steam railroad along a certain defined route, and established a definite time of completion. A contract was made on the 22nd day of the same month with the Southern Pacific Company, agreeing to such conditions, and specifying a distance tariff on all tonnage according to the Western Classification.

Actual construction was begun May 5th, 1908, and rapidly pushed. Temporary tracks were built around the heavier cuts and fills, and the laying of the steel progressed at a rate of nearly a mile per day, arriving at Siding No. 6, opposite the mouth of the Red Rock Canyon, on June 2nd. From this point grading was rapidly advanced to heavier work at the Summit, through Rademacher Pass, reaching Indian Wells October 31st, and the lower end of Little Lake Canyon, the latter part of November. Temporary track has been laid to the lighter work beyond, and it is expected that the road will be able to deliver freight at the southern end of the Haiwee Reservoir about the middle of February, 1909.

Auxiliary Line.

For the purpose of serving the south end of the Freeman Division, and Section No. 1 of the Jawbone Division, an auxiliary spur line of standard guage railroad has been constructed from the main line at a point near Siding No. 6, to a terminus in Dove Springs Canyon, with a maximum grade of 3½ per cent. The agreement executed with the Southern Pacific Company provides for the construction of this line at cost plus 10 per cent, operation and maintenance to be provided by the Los Angeles Aqueduct, and the ultimate salvage of the track material at any time within a period of five years.

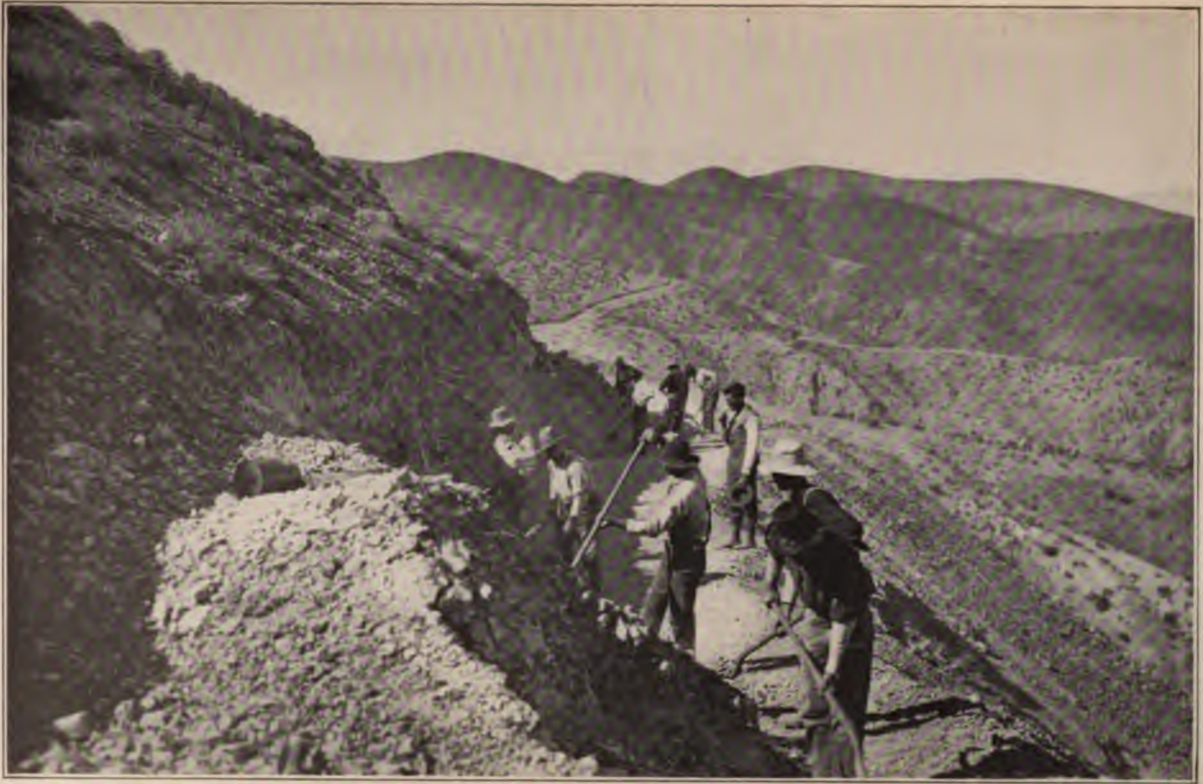
Cement Plant Tramway.

In order to secure the necessary tonnage of lime rock sufficient to operate the cement plant at its estimated capacity, an aerial tramway of 4,600 lineal feet, consisting of seventeen towers, upper and lower terminals and bins, together with the necessary track and traction cables, has been erected. This tramway descends an elevation of 900 feet and delivers the rock into a storage bin of 200 tons capacity. From the foot of the cable tramway, a narrow gage (3 foot) railroad has been constructed for 5½ miles, with a maximum grade of 5 per cent, following section lines as closely as possible, to avoid expensive rights of way. The Southern Pacific grade is crossed with a sub-grade crossing a short distance north of Sullivan Spur, and the road terminates, with the necessary sidings, at the crusher house of the cement plant.

The award for this work was made on September 11th, 1908, at cost plus 4 per cent. Track material and rolling stock were furnished by the City of Los Angeles, and the time limit was fixed at sixty days. Standard 35-pound rail and redwood ties were used and adequate siding trackage was established at the proper intervals. The rolling stock is composed of one special design twenty-five-ton engine and twelve side dump cars of ten-ton capacity. It is estimated that lime rock will be delivered to the crusher at a cost of not exceeding 40 cents per ton.

Wagon Roads.

Coincident with the establishment of railroad facilities has been the construction of an adequate system of roads and trails. This was especially necessary in the central portion of the Jawbone Division, from Sugar Loaf Mountain to Pine Canyon, where the Aqueduct location lies at an elevation varying from 900 to 1200 feet above the desert level. The most noteworthy of these road systems, called the "Gray Ridge Road" has been built under the direction of G. C. Ripley,



ROAD BUILDING IN THE JAWBONE DIVISION.

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Tunnel Superintendent, and forms a means of communication between the Division Headquarters at Siding No. 5 and the almost continuous chain of tunnels extending from the Jawbone Siphon south. Built with a maximum grade of 6 per cent, it develops distance on the main ridge and in its adjacent canyons, separating at the summit into two branches, which lead to the Compressor plants in Water and Sun Canyons. Auxiliary roads and a network of trails serve for all necessary haulage from these termini.

Anticipating the opening of the Grapevine Division, a similar system of road and trail communication is being prosecuted at that point. Conditions, while rigorous, do not present such difficulties as were encountered in the Jawbone Section, and, with a large force engaged, it is expected to push the same to a rapid completion.

Dating from the inception of Aqueduct construction, a total of nearly two hundred miles of roads and trails have been constructed on all divisions.

Wagon Haul.

Prior to the completion of the California and Nevada Railway to Siding No. 6, all materials necessary for preliminary construction and commissary supplies were transported by wagon haul from the Mojave warehouse north to the various camps. These materials included all lumber for bridges and buildings; pipe and fittings for water supply; cement; tools and powder for the building of roads and trails; wire, poles and hardware for both telephone and transmission lines; and all supplies necessary for the subsistence of from two hundred to one thousand men. With such volume of freight it was found both economical and expedient to advertise for bids for wagon transportation on the basis of main and branch road haul, the former item to embrace haul on the stage road from Mojave north, and the latter to apply to haulage from such main road over all branches feasible for travel with well broken freight teams. A contract was entered into December 30th, 1907, specifying a net price of 28 cents for main road and 30 cents for branch road haul per ton mile. This contract called for the distribution of approximately 1,000 tons of freight. A contract was also made December 11th, 1907, for a number of freighting outfits, the same being compensated for at certain prices for six, eight and ten-animal teams. A further contract, now in force, dated September 18th, 1908, has been made for the hauling and loading of gravel and other material. This contract was designed chiefly for the transportation of cement and gravel on the Mojave Division.

Traction Engines.

In the effort to reduce the cost of wagon haul below that of ordinary team transportation, trials have been made of traction engines of various design. It was found that the familiar types of engines, with comparatively narrow wheel treads, were useless in the deep dust and sand of desert roads. A special type, however, called the "Caterpillar" or "Paddlewheel" Engine—so designated from the peculiar construction of its rear and propelling wheels—has been placed in service with good results.

This engine, instead of having the large hind wheel commonly known, carries its weight on five truck wheels which run on a track of plow steel, so protected that it is nearly impossible for sand to reach the bearings. The hind wheels are of the sprocket type and engage an endless belt of "shoes" or platforms" which pass around the sprocket and center wheels, 78 inches distant, the latter acting as idlers. These platform wheels have the same tractive area as an ordinary round wheel, 54 feet in diameter.

While manufactured with either steam or gasoline power, the latter has been found best adapted for use on the Aqueduct. The motor used is of the four cylinder, vertical, water cooled type, with 6"x8" cylinders, developing 40 brake h. p. at 550 R. P. M. Distillate is used for fuel at a cost of less than 1 cent per h. p. hour.

The capacity of these engines naturally varies with the grade. Loads of from 15 to 20 tons are possible on level roads. Specially built trucks capable of carrying from 6 to 10 tons are used. Compressors, transformers and other heavy machinery, weighing from 7 to 10 tons, are easily transported over grades of loose sand ranging from 12 to 20 per cent, and around the sharp curves of mountain roads. Ordinary wagon transportation of such loads under like conditions would be an impossibility.

Accurate cost data has been kept of the performance of these machines, together with team haul, for the purpose of comparison. Recent work in the Jawbone and Mojave sections shows an average ton mile cost of 20 cents for engine haul, against an average of from 40 cents to 50 cents for team transportation.

WATER MEASUREMENTS.

The work of stream gaging in the Owens Valley, the records of which proved so indispensable in reaching the conclusion as to the available water supply and which were published in the "First Annual Report," has been continued under an arrangement whereby the Reclamation Service supplies a man, paying his salary, the Aqueduct paying all other expenses connected with the work.

It is pleasing to note that the data obtained since the publication of "The First Annual Report," confirms and fully sustains the deductions then made in the exhaustive and luminous analysis of the subject presented by Mr. Charles H. Lee. In his report, just submitted and herewith presented, he reiterates as a result of these continued observations that a constant flow equal to the full capacity of the Aqueduct can be maintained by the used of the proposed Haiwee Reservoir as a seasonal regulator and the Long Valley Reservoir, *or its equivalent*, as a regulator of the variations of flow from year to year.

The conservation and regulation of flood waters is a subject that at present is receiving more attention from the National Government than ever before—conservation, for the purpose of beneficial use as in irrigation and for power purposes, and regulation, for the prevention of disastrous floods and the improvement of the conditions and requirements of navigation in our inland water ways.

The conservation of waters may be attained either naturally or artificially and Southern California affords most notable instances of both methods. The Bear Valley, the Hemet and the Sweetwater Reservoirs are good examples of the latter, while the naturally stored waters in the San Bernardino, San Gabriel, San Fernando and Coastal Plain Valleys are fine examples of Nature's craft and handiwork. The cities of Los Angeles, Pomona, Long Beach, Santa Ana and many other towns of Southern California are wholly supplied by water so stored and fully one-half of the lands of the highly productive irrigated areas of this part of the State are supplied by ground water. Indeed, it may be said that had this source not been resorted to, the ultimate development of this country would have been reached ten years ago, as with very few exceptions, all the available sites for artificial reservoirs had been appropriated and put to use, and in some cases with disappointing results. The reason for this is that these reservoirs were drawn from on the assumption that they would be filled every year, whereas it is now well known that dry years may occur in groups, as for instance the seven years beginning with the winter of 1897-8 and continuing through the intervening years to and including the winter of 1903-04, in which period there was a deficiency of more than forty per cent below the normal precipitation for Southern California as deduced from the rainfall records of thirty years. It would have to be a great reservoir indeed, that would have capacity enough to meet such a contingency as this, nor would ordinary prudence be likely to suggest provision for it.

There is no doubt that even our great ground water basins are, in places at least, much overdrawn and it was the knowledge of this fact more than anything else that directed the attention of the water officials to the necessity of seeking remote sources of supply. The overdraft on ground water, however, affords its own limitations in the increasing cost of its extraction due to the depression of the water plane having the effect of making its use unprofitable.

Owens Valley, by its peculiar configuration, is splendidly adapted to the conservation of water as is amply shown by the well sustained flow of the river that drains it, considering the great variation in the precipitation on its watershed from year to year. The Valley, lying as it does between two high ranges of mountains receives the drainage of the great Sierra Nevadas on the west for a distance of more than one hundred and forty miles, discharged not by one or two large canyons near its head flowing through the lowest depression of the Valley to its outlet, but by over forty lateral streams distributed at more or less regular intervals along its entire length and debouching from the mouths of the canyons over porous debris fans that attain an altitude in some instances of nearly two thousand feet above the floor of the valley.

We have heard a large amount of discussion as to the benefits that might be derived from spreading the flood waters of our Southern streams over their delta fans, but there has always been a doubt as to the practicability of such an undertaking owing to the violence and short duration of our floods and the muddy condition of the water during those periods, making its absorption by the gravels difficult.

In the Owens Valley, Nature performs this very work on an enormous scale and under conditions that are exceedingly favorable, namely: clear water, very porous material, and long continued periods of flow in many small streams. The result of this process is abundantly evident in the numerous springs, great and small, that exist along the toe of the large mass of debris (in some places more than five miles wide) that has accumulated along the base of the great mountain range. Stronger evidence, even, than these springs is the broad belt of wet, and in some cases boggy land that with the exception of the rocky gorge above Bishop extends the whole length of the Valley. That this great area can remain in this constant state of saturation in a climate of such low humidity and high rate of evaporation as that of the Owens Valley speaks volumes for its reliability as a source of supply.

Mr. Lee, in addition to the continuance of his former observations of the stream flow, has been directed to make a thorough study of the ground water of the Valley.

WATER DEVELOPMENT AND DISTRIBUTION.

Water development and distribution for the past year has included the installation of four systems comprising two small reservoirs and a total of 398,161 feet of pipe line, ranging in diameter from one to six inches. The sources are streams, springs and wells. The work has been confined to the Jawbone, Mojave, Antelope and Elizabeth Divisions. The expenditures for this purpose have been approximately $79,000.

The systems comprise: 1. Sage Canyon Pipe Line, 2. Sage Canyon Pipe Line Extension, 3. Tehachapi-Jawbone Pipe Line with two branches, and 4. King's Canyon Pipe Line.

Sage Canyon Pipe Line.

The water supply for the Sage Canyon pipe line is procured from three springs and two open streams located about five miles from the mouth of Sage Canyon. The water is obtained through filtration galleries, carried through a two-inch pipe line at high pressure for a distance of two miles and into a collecting and sand box. Thence the water is carried through five miles of three and one half inch O. D. casing to the line of the Aqueduct, which it parallels for four miles to Red Rock Summit and is there discharged into a storage reservoir of 300,000 gallons capacity.

Sage Canyon Pipe Line Extension.

From the reservoir on Red Rock Summit, a pipe line 14 miles long with side lines wherever required, conveys an ample supply of excellent water for camp use and construction purposes along the Aqueduct Survey in the Jawbone Division to Water Canyon. Water is available at all points throughout its length.

Tehachapi-Jawbone Pipe Line.

The Tehachapi-Jawbone line is supplied from a well 225 feet deep at Proctor, a point near Tehachapi. The water is raised by a centrifugal pump, driven by a gasoline engine. The water is discharged into a reservoir of 200,000 gallons capacity and a four inch pipe line from this reservoir follows the Southern Pacific Railroad for about ten miles to a point a short distance south of the railroad station of Warren, where it joins the Aqueduct line at the intersection of the Aqueduct and the railroad, four miles north of Mojave. From here the pipe line follows the Aqueduct Survey north for 14 miles to Sun Canyon. About 6,000 feet north from the terminus of the Tehachapi

Jawbone line is the southern terminus of the Sage Canyon Pipe Line Extension. The intervening distance, which is the site of a tunnel, will be piped as construction work progresses. These two lines furnish a water supply along the Aqueduct for a distance of 35 miles.

Near the junction of the Aqueduct and the railroad at Warren a reservoir of 60,000 gallons capacity has been built. It is supplied from the Tehachapi-Jawbone line. From this reservoir, water is delivered through two miles of four-inch pipe to the warehouse, machine shops, etc., of the Aqueduct near Mojave. A pressure in excess of 100 pounds provides effective fire protection. A second branch of two-inch pipe parallels the Aqueduct for eight miles south.

Kings Canyon Pipe Line.

The source of King's Canyon pipe line is a mountain stream near Neenach, Cal. A line of four-inch pipe carries the water four miles to the line of the Aqueduct, thence along the Aqueduct for twelve miles to the North Portal of the Elizabeth Tunnel, where it is used for camp and construction use. Water is available for the Aqueduct at any point along its route.

A tabulation of sizes of pipe and distances is given herewith:

Sage Canyon Pipe Line—

3½	Inch	57,764 ft.	
2	"	9,564 "	
1	"	3,106 "	
			70,434

Sage Canyon Pipe Line Extension—

4	Inch	46,000 ft.	
2	"	15,400 "	
1	"	13,826 "	
			75,226

Tehachapi-Jawbone Pipe Line—

6	Inch	4,000 ft.	
4¼	"	17,590 "	
4	"	85,967 "	
3¼	"	21,512 "	
2	"	26,100 "	
1	"	30,826 "	
			175,995

Tehachapi-Jawbone Branch Line (Mojave Div.)—

2	Inch		11,370

Tehachapi-Jawbone Branch Line (Jawbone Div.)—		
1 Inch		11,078
King's Canyon—		
4¾ Inch	12,500 ft	
4 "	29,850 "	
2 "	8,994 "	
1 "	1,844 "	
		53,188
Total		88,161 feet

MECHANICAL DEPARTMENT.

November 1, 1908, the stationary mechanical equipment consisted of two hydro-electric plants, a third under construction, a steam turbo plant at the cement mill, two tunnel power plants on the Elizabeth Division, six tunnel power plants on the Jawbone Division, with necessary tunnel boring machinery, machine, and carpenter shops. The excavating machinery consisted of one hydraulic dredge on the Owens Valley Division, one Marion Model 40, and one Marion Model 20 steam shovel on the Mojave Division, and one Austin excavator now being erected on the Antelope Division. Designs for the excavating machinery have been originated or developed in the Headquarters Office. Machinery is erected under the supervision of Mr. Roderick MacKay, Mechanical Constructor.

One gas engine, friction-driven shovel for the Antelope Division, and one electrically driven shovel for the Jawbone Division will be delivered within a few weeks. Bids have been advertised for the machinery of another hydraulic dredge of larger size than the one now in service and this will be installed during the summer of 1909 on the Owens Valley Division. Four tunnel power plants will be built in the Saugus Division and three in the Grapevine Division.

Heavy repair work that cannot be done in the field is taken to the main shop at Mojave. This shop, 40 x 80 feet, is equipped with lathes, shapers, radial drills, pipe and bolt cutting machinery, grinders, etc. It is intended to install a steam hammer and other equipment later. Here there is also a carpenter shop, 40 x 60 feet, where freight wagons are repaired, portable houses fabricated and office equipment built. Smaller machine shops, each equipped with a lathe, drill press, emery grinder and saws, have been built at the portals of the Elizabeth Tunnel. They are described in the progress report for that Division. It is proposed to install these small shops at all tunnel camps.

TELEPHONE SYSTEM.

The desirability of a through telephone line became apparent in the early stages of the work. The main power lines parallel the Aqueduct location approximately 180 miles, requiring so much of the telephone line for the successful operation of the power system, and its completion was clearly essential to economy and dispatch in the preliminary and construction work as well as for the operation of the Aqueduct when completed.

It would have been difficult to construct a satisfactory telephone system, following on the poles of one 33,000 volt transmission system for 140 miles, on the pole of another independent system for 33 miles and paralleling a third for 25 miles, all with grounded centers, and the telephone line would have been inconvenient and unsafe for the uses intended. Estimates showed that the cost of power and telephone lines on the same 35-foot poles, thus limiting the spacing, would be as much, and in fact slightly more than the cost of power on 30-foot poles and telephones on 4 x 6 x 18 foot redwood poles which were determined upon.

The through telephone line is now completed from the Los Angeles City limits to Independence, Inyo County, Cal., a distance of approximately 230 miles, and material is purchased to extend it to the Intake. The first twenty-two miles to the Fernando Tunnel consists of two number 10 bare copper wires supported on D. P. D. G. glass insulators on the poles of the United States Long Distance Telephone and Telegraph Company, for which we pay a rental. The standard construction for the rest of the line consists of the same supported on oak brackets on 4 x 6 x 18-foot redwood poles spaced 160 feet. These poles are from the butt cuts of selected redwood. The estimated cost for the first twenty-two miles was $95 per mile and the actual cost $101 per mile. The average estimated cost for the various sections of the remaining 208 miles was $232 and the actual cost $188, which includes estimates, plans, location and supervision. The system is connected directly with the Los Angeles office by a pair of wires rented from the U. S. Long Distance Company from the city limits.

The line is divided into three sections by stations at Mojave and Cottonwood and in order to lessen the number of telephones on the line as well as that amount of business, local lines are constructed in Divisions where the work is heavy. These lines, including the branch to the cement plant, are constructed of No. 12 galvanized iron telephone wire and aggregate thirty-nine miles on the main line poles and forty-six miles on independent poles at a total cost of $7,230.

In order to insure safety the line is placed underground at each power line crossing. The Western Electric Company five-bar, 2500-ohm long distance telephone sets and protectors are used, of which twenty-five are connected on the main line and thirty-eight on the local lines at present at an approximate cost of $10.50 for each complete installation.

The total cost of the telephone system to date is approximately $50,000.

POWER DEVELOPMENT AND DISTRIBUTION FOR CONSTRUCTION PURPOSES.

Preliminary estimates and study showed that, for those sections in which the work is heavy and the power requirements considerable, electrical energy could be generated at certain central points and delivered at the work at a lower cost and with more satisfactory results than could be realized by the distribution of the necessary generating machinery and fuel along the line. It was further shown that hydro electric power could be developed along the Division Creek and the Cottonwood Creek and delivered to all points from the Intake in the Owens Valley to the south end of the Jawbone Section, giving reliable power at from one-quarter to one-third less cost than it could be furnished in any other way. In each case, interest on the investment and total depreciation of the systems, with the exception of a reasonable return from the machinery and copper, were included in the costs.

The power systems determined upon, and which are either completed or the necessary machinery and materials contracted for, consist of three hydro-electric plants, and 188 miles of 33,000-volt transmission lines, with twenty transformer stations, some of which are portable. The generating plants are Division Creek No. 1; Division Creek No. 2 and Cottonwood Creek, with a total continuous capacity of 2600 K. W. at the switchboard and which can be expected to deliver under actual conditions of operation and of load, an amount equivalent to 2100 K. W. continuously or for twenty-four hours per day through the year. These plants will furnish power at all points from the Intake to the Pinto Hills, or South end of the Jawbone Division, which district is covered by 146 miles of main transmission line and six miles of branch lines in the Jawbone Tunnel Section. The remaining thirty-six miles of transmission is near Saugus, reaching all points from the south portal of the Fernando Tunnel to the north portal of the Elizabeth Tunnel and connecting with the Castac sub-station of the Edison Electric Company, from which company power is purchased for this part of the work.

Division Creek No. 1 Power Plant.

Hydro-electric plant No. 1 on the Division Creek has a maximum continuous capacity of approximately 125 K. W. and consists of one Westinghouse 440-volt, 3-phase, 60-cycle electric generator with belted exciter; one Doble water wheel of 185-H. P. capacity with stationary needle nozzle and stream deflector operating under 400 feet of effective head and one bank of General Electric step-up transformers. From the diversion dam in the creek a canal 300 feet in length leads to the forebay, whence a penstock 5700 feet long conveys the water to the water wheel. The 5700 feet of pressure pipe is all twelve inches in diameter and is made of riveted steel plates varying in thickness from No. 16 to No. 10 gauge. This small plant was installed in advance in order to try out and operate the first hydraulic dredge in Owens Valley and has been in operation since April, 1908. Estimated cost of hydraulic development and power house complete was $16,200. The actual cost was $15,130.

Division Creek Power Plant No. 2.

Hydro-electric plant No. 2 is located on Division Creek near the forebay of Power plant No. 1. The diversion for this plant will be made about two miles further up the stream. An artificial reservoir will be constructed of capacity sufficient to carry fluctuations of load 30 per cent above normal for a period of eight hours. From this reservoir a pressure pipe 10,500 feet in length leads into the power house. The upper 6209 feet of this pipe is made of eighteen-inch riveted sheet steel, and the lower 4209 feet of fifteen-inch O. D. lap welded pipe. The plant will have a maximum continuous capacity of 600 K. W., and will consist of one Westinghouse 2200-volt, 3-phase, 60-cycle electric generator, with exciter mounted on shaft direct connected to one Doble water wheel with stationary nozzle and auxiliary nozzle, operating under 1200 feet of effective head at 600 r. p. m. and one bank of Westinghouse step-up transformers. This plant will be permanent in character with a concrete house and provided with one extra transformer and extra machinery parts for reliability. It will be in operation about January 1, 1909. The estimated cost, including hydraulic development, is $57,000.

Cottonwood Creek Power Plant.

The principal source of power will be the Cottonwood Creek Hydro-electric plant, which is laid out for two generating units; one belt-driven and one separately driven direct connected exciter and for the entrance of the transmission line from the two Division Creek plants and the line going south 11½ miles. From the diversion dam in Cottonwood Creek a covered concrete conduit 10,827 feet in length is constructed on grade along the hillside and connects with a rubble concrete forebay. From the forebay a riveted sheet steel penstock conveys the water to the wheels. The penstock consists of 525 feet of twenty-four-inch pipe and 4710 feet of twenty-two-inch pipe, all riveted steel, and varying in thickness from No. 10 gauge to one-half inch. This plant is complete and in operation with the exception of one generating unit and one exciter unit and is constructed in the same substantial way as Division Creek No. 2 and provided with spare parts.

Each unit will have a separate bank of Westinghouse step up transformers. Unit No. 1 consists of a 2300-volt, 3-phase, 50-cycle generator direct connected to one Pelton water wheel operating under 1200 feet of effective head with needle deflecting nozzle controlled by a Lombard type "R" governor and has a maximum continuous capacity of 937½ K. W. The unit No. 2 will consist of a similar generator direct connected to a Doble wheel with stationary needle nozzle and auxiliary nozzle, thus giving it a peak load capacity in excess of the 937½ K. W. The estimated cost to date, including complete hydraulic work is $81,600. The actual cost to date is $76,040. The estimate to complete is $23,500.

Transmission Lines and Transformer Stations.

Approximately twenty-six miles of the thirty-six miles of 33,000-volt, 3-phase transmission line near Saugus was completed August 1, 1908, reaching the portals of the Elizabeth Tunnel. This line is built of thirty-foot cedar poles, an average distance of 200 feet apart; one six-foot and one fifteen-inch cross-arm per pole, supporting three number 4 solid copper wires on seven-inch two-part porcelain insulators. The estimated cost of this line was $881 per mile and though the line was built in bad weather during February and March the actual cost was kept within the estimate, or $868 per mile. This cost includes all engineering, location and brushing. The lowest figure guaranteed by contract for distribution and construction was $45 per mile or 17½ per cent in excess of the estimate for this part of the total.

The 33,000-volt, three-phase line connecting the Division Creek and Cottonwood Creek power houses and furnishing power along the way will be completed about January 1, 1909. The main line, 106½ miles south from Cottonwood and six miles of branch line in the Jawbone Division are completed and power is being delivered to five tunnel stations. The construction is the same as for the lines near Saugus, except that because of the excessive haulage costs and the temporary character of the line a special twenty-eight-foot pole, built up of lumber and spaced 175 feet is used. The estimated cost was $994 per mile and the actual cost $795. This line was built in good weather by energetic line foremen and good men. The cost includes all location and supervision.

The three hydro-electric plants are not larger than desirable to insure reliable and sufficient power at all times for the construction work from Jawbone north, but the average power requirement delivered at the power house probably will not exceed 1600 K. W., while the average output, as stated above, should be 2100 K. W. through the year. Hence the feasibility of building a branch line from this system to the cement plant near Tehachapi at a cost of about $30,000 is being considered. This would bring about a saving in fuel oil sufficient to cover the investment in twelve to fifteen months and a corresponding net gain each month thereafter.

MEDICAL DEPARTMENT.

The organization of a Medical Department for and in conjunction with the construction of the Los Angeles Aqueduct, and for the benefit of its employees, was authorized by a resolution of the Board of Public Works. On May 13th, 1908, a contract was signed between the Board of Public Works and Drs. Rea Smith, E. C. Moore and Raymond G. Taylor, wherein the latter agreed to undertake the organization, equipment and administration of such a Department.

Synopsis of Contract.

The Department is supported by assessments from all Aqueduct employees, including those of Contractors and Sub-contractors.

Assessments are $1.00 monthly from those receiving a wage of $40.00 or over per month, and 50 cents from those receiving less. Any employee is entitled to Medical, Hospital and Surgical service when needed, except for venereal disease, intemperance, vicious habits, injuries received in fights, or chronic diseases acquired before employment.

Hospitals are of two kinds: Field, erected by the city at suitable points, with accommodations for six patients, surgeon and nurse; and General, located in Los Angeles. The city is to provide wagon transportation for supplies from the railroad to suitable points of the work, and wagon transportation for sick and injured on the work, to Field Hospital or railroad.

Meals, food, water, etc., are furnished by the city and its Contractors to the Medical Department at regular rates at the various camps. Gasoline is furnished by the city at cost, plus 10%. The city grants the use of the telephone and telegraph lines owned and controlled by it.

Contractors agree to furnish and equip Hospitals, provide Physicians, Nurses and Stewards; to furnish drugs, nursing and medical and surgical attention; to furnish board for bed patients in the Field, and all patients in the General Hospitals; to furnish railroad transportation, where necessary, to the General Hospital and return fare, provided patients re-enter Aqueduct service within five days of their discharge from Hospital.

Contractors are empowered to make sanitary inspection and establish quarantine if necessary.

Organization.

In the practical working out of the plan contemplated in the Contract, several additions, with the idea of giving better and more efficient service, have been made.

Three classes of Hospitals have been established: Camp or Tent, Field or Division, and General.

A Camp or Tent Hospital is located in every camp on the work. It consists of a 14x16 wall tent, framed and floored, and is practically wind and rain proof.

Each division is divided into sections.

The Camp Hospitals in each section are in charge of the Hospital Steward, who is provided with a saddle horse and makes daily trips to all camps in the section.

Field or Division Hospitals are located at Division headquarters and, where practicable, on the railroad. They are built of wood, and normally accommodate six patients (the Jawbone Hospital accommodates twelve). Hospital Steward and Surgeon. They are headquarters for the Division Surgeons, and distributing points for supplies.

The General Hospital is the California Hospital, located at Los Angeles, and all severe cases that cannot be properly cared for in the field are removed to it. Arrangements have been made by the Contractor with the management of the Hospital whereby Aqueduct patients requiring General Hospital care are received and given exactly the same care and attention as any private patient.

Surgeons and Stewards.

Surgeons are of four classes: 1st—Consulting Surgeons, who are Specialists in their various lines. 2nd—Chief Surgeons, in direct charge and management in the Department. 3rd—Assistant or Division Surgeons, in charge of Field or Division Hospitals and tributary Camp Hospitals and Stewards. 4th—Local or Resident Surgeons, who, while not located at a Field Hospital, reside in the neighborhood and are subject to call at any time.

Hospital Stewards are located at all Field or Division Hospitals and at such Camp or Tent Hospitals as the necessities of work demand. Their duties are to prepare food, administer the details of treatment and nursing, and give first aid to the sick and injured. They are under the supervision and report to the nearest Division Surgeon.

Inspection and Sanitation.

An inspection trip is made by the Contractors over the whole line of the Aqueduct once a month. Short trips to the principal points on the work are made several times per month, as necessity may require.

Sanitary conditions are inquired into, not only on these trips of inspection, but constantly by the Division Surgeons and the Hospital Stewards, who are over the ground daily. Unsanitary conditions of the camps, bunk houses, mess house, commissary, water supply, drains or toilets, if found, are at once brought to the attention of the engineer in charge and immediately remedied. The camps are well policed at this date and in good condition.

Equipment.

Camp or Tent Hospitals are equipped with stoves for heating and simple cooking, and cooking utensils, basins, irrigators, etc., and material for doing ordinary surgical dressings; medicine chest and medicines; three cot beds with bedding; stretchers for emergency use in case of accident on the work.

Field or Division Hospitals.

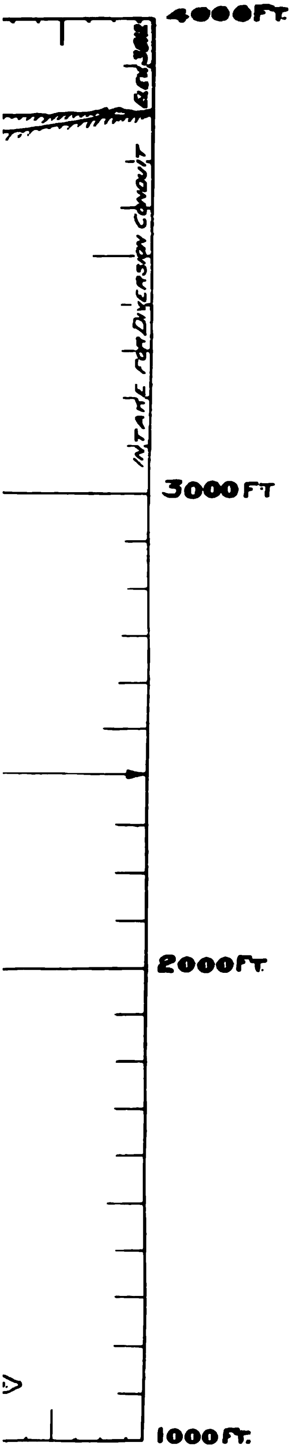
Field or Division Hospitals are provided with operating room and appliances for doing practically anything that may be required in the medical or surgical line; a complete supply of drugs and dressings and disinfectants; iron cots with sanitary springs, wool mattresses and bedding; stoves and utensils for heating and cooking; bath tub, slop hopper and sewer connections.

General Hospital.

The General Hospital is one of the best and most completely equipped Hospitals on the Pacific Coast, and all its conveniences and equipment are at the disposal of this Department for the benefit of its patients.

Location of Hospital, Surgeons and Stewards.

Camp or Tent Hospitals have been erected at all the principal camps except those camps having Field Hospitals. About fifteen are



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TILDEN FOUNDATIONS.

in use at present are more [illegible] of construction systems. Division [illegible] and equipped at [illegible] Dove Springs and [illegible] Surgeons [illegible] and Consulting Surgeon [illegible] Rogers at Los Angeles [illegible].

The following is a summary of the cases treated [illegible] ing of the [illegible].

Surgical cases treated	[illegible]
Medical cases treated	[illegible]
Total number of cases treated	[illegible]
No. of bed patients in Division hospitals	[illegible]
No. of days in Division hospitals	[illegible]
No. of bed patients in General Hospital	[illegible]
No. of days in General Hospital	[illegible]
No. of visits made to Camps	[illegible]
No. of Consultations at Office	[illegible]
Deaths from disease	[illegible]
Deaths from accident	[illegible]

Headquarters and Business Offices.

Headquarters and Business Offices are located at [illegible] South Spring St., Los Angeles, California, Suite [illegible] Lissner Bldg. and all communications to the Department, of whatever nature, should be sent to this address.

DIVISIONS OF THE AQUEDUCT.

Division 1.—Long Valley.

The Long Valley Reservoir site is situated north of Owens Valley in the foot-hills of the Sierra, in Townships 3 and 4 South, Range [illegible] East, M. D. M. The elevation of the bed of the stream at the dam site is 6,660 feet, and the elevation of the top contour as surveyed is 6,810 feet, providing for a depth of 150 feet of water. With this depth of water, a storage capacity of 340,980 acre feet can be obtained.

A gaging station has been maintained on the Owens River below the Long Valley Reservoir site at a point known as Round Valley since

August, 1903. These measurements indicate the quantity of water available for storage in the Long Valley Reservoir site. They are given in detail in the portion of the report relative to hydrographic investigations.

Division 2.—Owens Valley.

This Division extends from the point of diversion on the Owens River to Cottonwood Creek, near Owens Lake, and is 222,200 feet in length. The first 110,000 feet are located on the floor of the Owens Valley. The line then passes along the base of the Alabama Hills for a distance of 77,000 feet and after passing the Alabama Hills, it skirts the base of the Sierra Nevada Mountains on the westerly side of Owens Lake through an even, sloping delta formation where the excavation as a rule will be relatively easy, but where some large bowlders will be encountered in the washes from the mountain canyons.

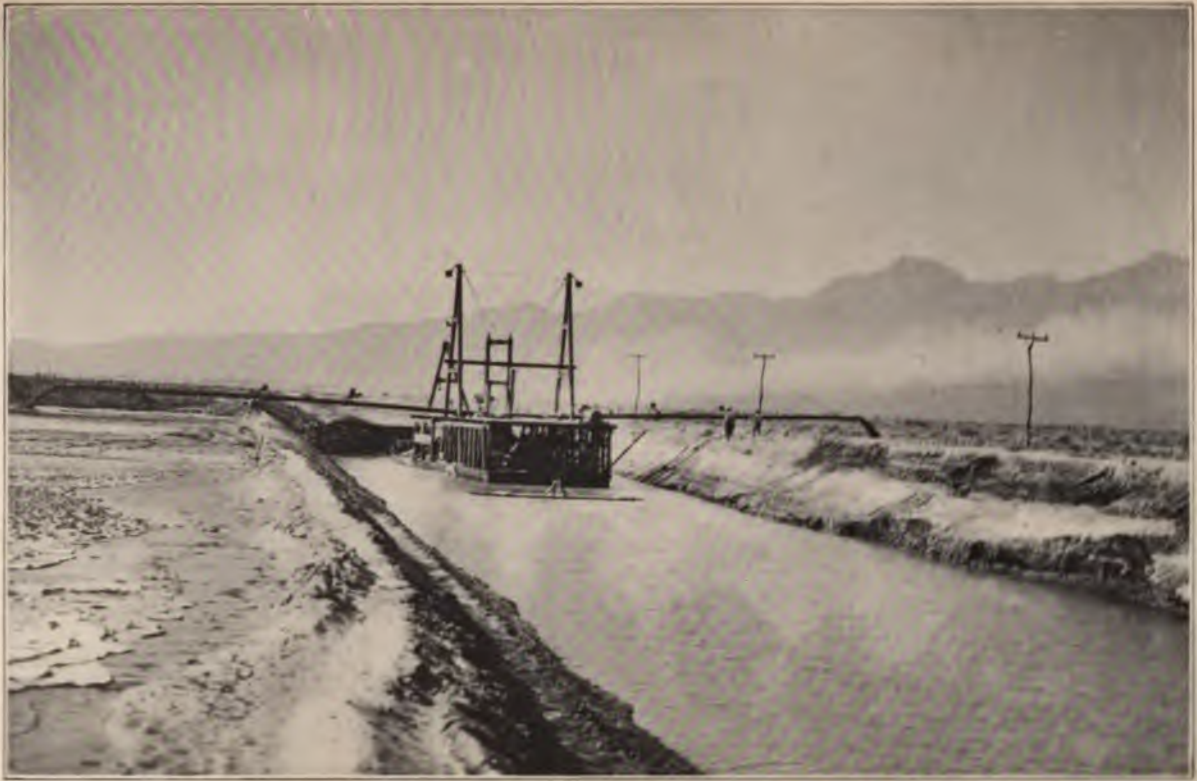
The elevation of hydraulic grade at the point of diversion is 3814.83 feet, and the elevation at the south end of the Division is 3773.8 feet, the total fall in the Division being 41.03 feet. The grade at the Intake is controlled by the elevation of the Black Rock Spring, which discharges a continuous flow of twenty cubic feet per second of water of a high quality. The slope of the canal in this section is flatter than in the other divisions of the work because of the necessity of utilizing the Haiwee Reservoir to its fullest capacity. These two points, the elevation of the Black Rock Spring and the maximum flow line of Haiwee Reservoir determine the grades of the canal for its first sixty miles through Divisions 2 and 3.

The first twenty miles is to be excavated by hydraulic dredges, and the balance of the work will be done by power shovels. The dredging operations are described in the foregoing forecast of work.

The location surveys for Division 2 have been completed during the fiscal year. Three power plants have been constructed in this Division and telephone and power transmission lines built, as described in the portion of the report relating to electrical equipment. A wagon road has been constructed from a point known as Diaz Lake to Cottonwood Creek, and also up Cottonwood Creek for a distance of three and one-half miles. Mr. Harvey Van Norman is in charge of the Division. The present working force is 142 men.

Division 3.—Olancha.

The Olancha Division extends from Cottonwood Creek in Owens Valley to and including the Haiwee Reservoir. It is 96,551 feet in length; the elevation of hydraulic grade at the north end of the Division is 3773.8 feet, and at the south end of the canal 3759.3 feet, thus provid-



DREDGE NO. 1—LOS ANGELES AQUEDUCT.

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LENOX AND
[illegible]

ing for a total fall of 14.5 feet. Final surveys have been made for the reservoir and for the canal line, but some revision work in the location of the canal line is now being carried on. The nature of the canal work is all power shovel construction of an easy character. Telephone and power lines have been constructed across this Division and a wagon road has been built around the west side of the Haiwee Reservoir. A pipe line has been constructed 20,100 feet in length, six and eight inches in diameter, from the mouth of Haiwee Canyon to the southern dam site for the purpose of furnishing a water supply for building the Haiwee Dam by the hydraulic process. The proposed progress and method of work is further described on page — of this report. The capacity of the canal leading into the Haiwee Reservoir from the Owens River will be 900 cubic feet per second, to permit of the discharge of flood waters from the main river and its tributaries crossing the canal. These will here be regulated and liberated from the reservoir at a uniform flow of 420 cubic feet per second. The capacity of the main canal at the diversion point will be 800 second feet, and this will be increased as various tributaries are passed until the capacity of 900 second feet is obtained at Cottonwood Creek. Mr. A. E. Keller, Assistant Engineer, is completing the location surveys.

Division 4.—Rose Valley.

Rose Valley Division extends from the south dam of the Haiwee Reservoir a distance of 77,858 feet. The first several miles will be through a broad canyon, and beyond this it will be through an open valley of gentle slope to Little Lake Creek. The elevation of the canal leaving Haiwee Reservoir is 3698.0 feet and at the southern end of the Division it is 3540.82 feet, thus providing a fall of 157.18 feet. The fall of the canal for the first three miles is 130.14 feet and beyond this point the slope is .4 feet per thousand. It will be possible in the future, if it is found desirable, to build a power plant in the canyon capable of producing 4,960 H. P.

Final location surveys have been made in this Division and power and telephone lines have been built along the line of the Aqueduct.

Division 5.—Grapevine.

The Grapevine Division extends from Little Lake Creek to the south end of the Indian Wells Canyon. It consists of 88,354 feet of canal, 25,729 feet of tunnel, and 14,228 feet of flumes and siphons. The elevation of hydraulic grade at the north end of the Division is 3540.82 and at the south end 3370.47, a total fall of 170.35 feet. Next to the Jawbone Division, this is the most difficult of all the Divisions of the Aqueduct. The character of the country is rugged, and in the central portion of the Division hard rock is encountered. The tunnels are mostly located in the northern end of the Division, and trails have been built between the portals of these tunnels A wagon road is being constructed up the Soda Springs Canyon to grade, and a double heading tunnel driving plant will be built at this point, from which 6,000 feet of tunnel must be driven in each direction. These tunnels, however, are broken into several sections by openings. A system of wagon roads is also being constructed along the proposed line of the Aqueduct in the southern end of the Division. The material here is mostly soft granite covered with several feet of soil. An order has been placed for pumping machinery and pipe lines will be laid conducting the water along the line of the Aqueduct throughout the Division. This water will be under gravity pressure for the northern part of the Division, but will have to be pumped to grade in Grapevine and Sand Canyons. Headquarters have been constructed in Grapevine Canyon and power and telephone lines have been built. The railroad has reached a point opposite the southern end of the Division.

Division 6.—Freeman.

This Division extends from Indian Wells Canyon to the Red Rock Summit. This portion of the line lies across an open plain where the construction will be both simple and cheap. The Division consists of 106,512 feet of canal, and 5,109 feet of flumes and siphons. The hydraulic grade at the northern end of the Division is 3370.47 feet and at the southern end, 3320 feet, providing for a fall of 50.47 feet. Final location on this Division is complete. Power and telephone lines have been constructed, and a pipe line has been built to the Red Rock Summit from Sage Canyon along the line of the Aqueduct, from which water can be obtained under pressure.

Division 7.—Jawbone.

The Jawbone Division begins at Red Rock Summit at an elevation of 3320.00 feet and extends to the Pinto Hills at an elevation of 3171.04 feet. The length is 119,795 feet, of which 60,657 feet is canal, 43,658 feet is in tunnel and 15,480 feet consists of flumes and siphons. The total fall consumed is 148.96 feet. The topography for the major part of the distance is exceedingly rough, consisting of granitic mountains and sandstone bad lands. A part of Section 1 comprises a stretch of level, easy country with construction in indurated, stratified sands.

Extensive surveys were made in this Division in selecting the most economical location. Complete topographic data was compiled on a scale of 100 feet to the inch for the 22.7 miles and definite location made on these topographic sheets. December 1, 1907, [illegible] miles of final location had been run. The party, in charge of Mr. [illegible], Assistant Engineer, was continued in the field and the final location was completed early in the spring of the present year.

In this interval the preliminary construction features of the Aqueduct were begun. Among the most important of these was the development and distribution of an adequate water supply from one end of the Division to the other, and also the construction of a large amount of roads and trails to make accessible the line of the Aqueduct which lies 1200 feet above that of the Nevada-California Railroad and the floor of the Mojave Desert. Water development in the Jawbone is discussed at greater length in the report of Mr. [illegible]. Road building has included the construction of a road from Mojave to Jawbone Canyon, thence through Section 1 to Red Rock Summit as a means for general freighting of materials and supplies. In addition, roads and trails lead up to the Aqueduct line wherever required. The Gray Ridge road of four and one-half miles with a 6 per cent maximum grade, was blasted out of rock for much of the distance. Eighty-two miles of road and trail have been constructed in this Division at a total cost of $62,500. The first eighteen miles of the Nevada and California Railroad was placed in operation June 30, which greatly facilitated progress.

There are twelve camps on the Division, all of which are connected with the City's long distance telephone line which extends from the Los Angeles Headquarters to Independence. The electric power transmission line also traverses the Division and October 17th began the furnishing of electrical energy for the driving of tunnel and excavating machinery. This with the subject of telephones is more fully discussed in another part of this report.

It was the desire of the Board of Public Works that the construction of the Jawbone Section should be by private contract and advertisement to this end, steel siphons excepted, was made May 29, 1908. Contractors were given every opportunity to avail themselves of a thorough knowledge of the conditions under which the work must be done. The Division was separated into three sections for bidding and proposals were received for the whole or in part. Bids were opened by the Board of Public Works July 27 and rejected four days later as being too high. Six bids were submitted for the construction of the entire divisions. The lowest was for $2,294,201.64, with cost plus ten per cent for extra work. The estimate of Aqueduct engineers is $1,956,578. These figures do not include the cost of cement, steel or freight from the nearest railroad station. Upon the rejection of bids, Aqueduct engineers were instructed to proceed with the construction under force account. As far as the work has proceeded the cost has been less than one-half of that proposed by the lowest bidder.

From the study of the conditions it was decided to build six permanent camps—at Pinto, Midway, Pine Tree, Water Canyon, Sun Canyon and Sugar Loaf—and to do all the tunnel work in Sections 2 and 3 from these camps. Air drills and requisite machinery have been purchased for these camps and installation is now almost complete. It has been determined to work the Pinto tunnels by hand and to double the equipment of machinery in Sun Canyon because of the hardness of the materials encountered. At each of these points tunnel power houses very similar in design, dimensions and equipment to the power houses in operation at the portals of the Elizabeth Tunnel are being built, as well as mess halls and bunk houses for the men.

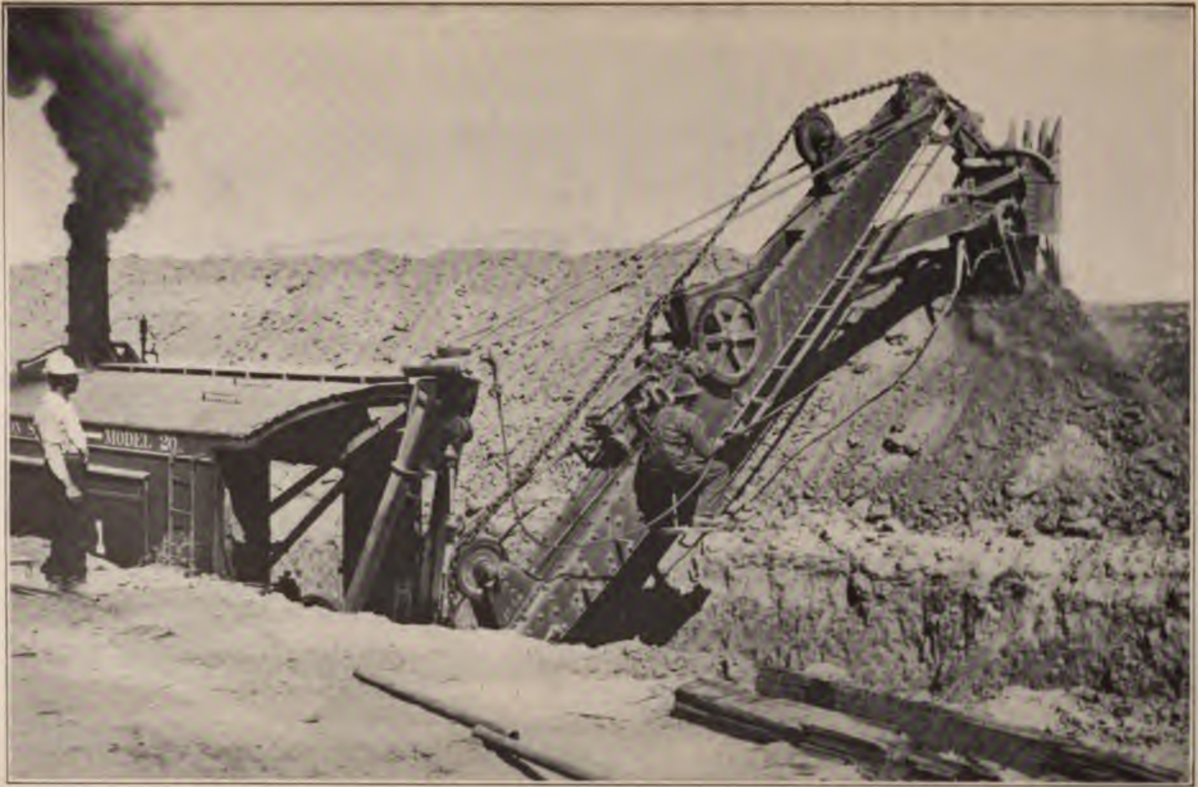
Cinco, on the Nevada & California Railroad, has been chosen as a suitable point for the establishment of permanent headquarters. These are now complete and include offices, a hospital, cottages, bunk house, mess hall and a central warehouse. Subsidiary warehouses and offices have been erected in Sections 1 and 3.

Permanent construction, November 1, was in progress at twenty-eight tunnel portals under the supervision of Tunnel Superintendents John Gray, T. F. Flannigan, G. C. Ripley, Preston and Bates. October 31 there had been completed 4,210 feet of tunnel at an average cost of $11.00 per foot, with every prospect that this will aggregate 10,000 feet by January 1, 1909. Making the fills and building small culverts was begun on Section 1, November 10, 1908. An electric shovel will be installed on this Section about December 1st. Concrete work can begin as soon as cement is available. The present working force on the Division is 1203 men.

Division 8.—Mojave.

The Mojave Division extends from a point known as Pinto, where the Aqueduct leaves the rough mountain district of the Jawbone and enters upon the Mojave Desert to the north end of crossing of Cottonwood Creek in Antelope Valley, the total length of the Division being 148,750 feet, all of which is canal in open country of easy construction. The grade elevation of the north end of this Division is 3171.04, and at the south end 3118.94, thus providing a fall of 52.10 feet. Telephone lines have been built, roads constructed and a water supply furnished under pressure along the entire line of the Aqueduct.

At the present time there are two steam shovels at work in this



STEAM SHOVEL EXCAVATING CONDUIT IN MOJAVE DIVISION.

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TILDEN FOUNDATIONS.

Division, and an Austin excavator is being erected. Steam shovel No. 1 began work in September, 1908. Four thousand five hundred twenty-five feet of canal have been excavated and 4032 feet lined. The shovel is of the Marion Model 20 type with an extra long boom. Shovel No. 2 began work in October and is a Marion No. 40 type with an extra long boom. Shovel No. 2 is working from the Southern Pacific Railroad north, and has excavated 2947 feet of canal and 1685 feet have been lined. A progress of 2000 feet a month can be made with each of these machines. The Austin excavating machine is being erected at a point about ten miles from Mojave. This machine has a templet designed to be an exact section of the ditch and the cutting buckets are arranged in such a manner that the exact section of the canal will be excavated.

Division 9.—Antelope Valley.

The Antelope Valley Division begins at the north end of the Antelope Valley Cottonwood Siphon at an elevation of 3118.94 feet and extends to the Fairmont Reservoir at an elevation of 3035.37 feet. The length is 138,940 feet, of which 101,525 feet is canal, 12,555 feet is in tunnel and 24,860 feet flumes and siphons. The total fall is 83.57 feet. The first three miles are largely tunnels in sandstone; the balance is in easy rolling country.

17.3 miles of location surveys had been run November 15, 1907. The remaining 9 miles of location were completed January 15, 1908 at which time the engineering corps was detailed to the Jawbone Division.

During the survey and after the party returned to the Division in August, a number of test pits were dug. These ranged in depth from two feet to a maximum of 10 feet depending upon conditions, and were put down wherever there was an indication in the change of formation. The results of this work show a decomposed granite in some instances, but the major part of the excavation will be in earth.

Approximately twelve miles of this Division extending north from the Fairmont Reservoir to the south end of the Antelope Valley siphon were ready for the inspection of contractors during September. This includes 1485 lineal feet of lined tunnel and 58,625 lineal feet of lined and covered canal designed for a normal flow of 430 second feet. Advertisement of bids to be opened November 30, 1908, was made by the Board of Public Works, October 12, 1908.

In preparation for construction, the work of providing a water supply was begun in June with the laying of the King's Canyon pipe line. King's Canyon is almost half way between Fairmont and Neenach, on the south side of Antelope Valley. A 4½-inch O. D. casing pipe line has been laid from the Diversion point in the Canyon, approximately 4 miles from the Aqueduct location to a point one mile from the line. At this place there is a diversion. A 4-inch O. D. casing pipe has been laid easterly along the Aqueduct location to the North Portal of the Elizabeth Tunnel, a distance of 6 miles, and a 2-inch standard pipe is being laid westerly for the same distance.

The telephone line has been extended to the engineering headquarters, 2 miles west of Fairmont with a branch line to the Division warehouse.

Actual construction, for which allowance is to be made should the work be let by contract, was begun September 10th. November 1st approximately 5,000 cubic yards of earth had been excavated from the portal cuts and points on the location too high for economical excavation by power machinery. Work is now in progress on four small tunnels near Fairmont, and a total distance of 180 feet had been bored. The present working force on the Division is 86 men.

Division 10.—Elizabeth.

The Elizabeth Division includes the Fairmont Reservoir and the Elizabeth Tunnel. The elevation at the north end is 2960 and at the south end, 2932.78 feet. The friction head consumed is 27.22 feet. Construction provides for the building of the Fairmont Reservoir dam by the hydraulic sluicing method and the boring of 27,215 feet of tunnel through hard rock.

Elizabeth Tunnel.

The Elizabeth Tunnel is the opening by which the waters of the Aqueduct will flow through the Coast Range. The north end will drain the Fairmont Reservoir and the south end will empty into the pressure canal and pipe above the first power site in San Franciscquito Canyon. As the tunnel will be under 86 feet head, or 34.4 pounds pressure when the reservoir is full, extra precautions are taken to insure permanency of back-filling and tunnel lining.

Of the 27,215 feet of tunnel, 355 feet is in open cut, which gives 26,860 feet from portal to portal. The dimensions are 12 feet 4 inches by 12 feet 9 inches, giving an excavation section of 5.02 cubic yards per lineal foot. The estimated time for completion is five years which necessitates an average speed of eight feet per day from each heading. The north half of the tunnel is located in a disrupted granite in which fissures varying from a few inches to one hundred feet in one instance have been encountered. The latter is probably a deeply eroded ancient surface channel. The smaller fissures are filled with talc and crushed granite, the larger with granitic wash. A depression known as Elizabeth Lake Valley crosses the tunnel line midway between the portals, containing three bodies of water, the central of which is directly over the tunnel line, the surface of the water being 285 feet above tunnel grade. Three wells were drilled in the Valley along the tunnel survey to ascertain the depth to and condition of the bed rock. In each of these wells a solid formation was encountered at a depth of 90 feet. From 90 to 115 feet was in a decomposed granite, which at the latter depth gave place to solid granite. The average cost of drilling was about $2.00 per foot. The original plans included a shaft in this valley but the satisfactory evidences of the formation and the progress being made at both portals lead to the abandonment of this feature.

North Portal.

Ground was broken in the portal cut at the north end, October 6, 1907 and the heading was opened November 1st. A temporary compressor plant driven by a 35 horse-power Marine gasoline engine was installed in December, 1907, and used at intervals until April 1st, 1908, the service being very unreliable and unsatisfactory. By May 1st this had been replaced by much permanent equipment which now consists of the following:

2—520 cu. ft. Franklin 2-stage air compressors, each belt-driven by a 100 h. p., 440-v., A. C. induction motor, supplying compressed air for rock drills, etc.

1—Fairbanks-Morse 100-K. W. Motor generator set, supplying direct current at 220-volts for operation of one 6-ton electric locomotive, used in tunnel traction, one No. 7 Root Blower and lights for tunnel illumination.

7—Model 6-A Water Leyner Rock Drills installed November 1st., displacing piston type drills formerly used. The tunnel track has been laid with 35-pound steel rails, the use of heavy steel being amply justified by the freedom from delays due to derailments.

The following buildings were erected on the ground:

3 24-man Bunkhouses, 78′x36′.
1 100-man Mess House, 1935 sq. ft.
1 Office, 24′x48′.
1 Residence for Engineer 24′x28′.
1 Residence for Clerk, 24′x42′.
1 Six-bed Hospital, 24′x35′.
1 Powder Magazine and Thawer.
1 Storehouse, for Tunnel Supplies 30′x80′.
1 Warehouse, for Commissary Supplies 12′x30′.
1 Blacksmith Shop 30′x30′.

1 Change Room, 12'x14'.
1 Timber Shed, 12'x20'.
1 Barn for 20 head of Stock 33'x60'.
1 Power House with Concrete Transformer Station 40'x80'.

Reservoir and tanks have been constructed, connected with a distributing system of about 5,000 feet of pipe lines. All buildings are piped for water and wired with electric lights.

Power is supplied from the Castaic Sub-Station of the Edison Company's Kern River transmission line, over a single pole line of No. 4 bare copper wire, under pressure of 30,000 volts. This line was built during February and March, 1908, and was available for use at the North Portal on May 1st., six months after the opening of the Portal. This current is transformed at the power house to a pressure of 440 volts by three 125-K. W. transformers, which are enclosed in separate rooms of fireproof concrete construction.

The machine shop is equipped with a number of small power-driven tools, including a lathe, a drill press, an emery grinder, a hack-saw, a drill sharpener, an air driven power hammer and a circular saw; these tools enable the local mechanical force to make all minor repairs to the mechanical equipment on the ground.

Work at the heading from the North Portal was in progress without intermission until August 15, 1908, when a body of saturated sand and gravel was encountered on crossing the channel before mentioned, causing a heavy run into the tunnel and extensive caving overhead. As the North shaft was then being sunk, it was deemed advisable to allow this wet ground to drain itself, and work was discontinued in the heading until October 1.

The following table shows the progress, unit costs and character of ground to November 1.

Month.	Progress, Feet.	Unit Cost.	Formation.	Method of Excavation.
Nov., 1907	165	$14.66	Disintegrated granite.	Full size heading. Hand work.
Dec., 1907	142	21.30	Blocky, soft granite.	Hand and mach. work. Upper heading.
Jan., 1908	115	37.60	Hard granite, soft talc seams.	Full section. Mach. work.
Feb., 1908	162	27.80	Hard granite, soft talc seams.	Lower heading. Machine work.
Mar., 1908	135	41.60	Very hard, blocky granite.	Small lower heading. Hand work.
Apr., 1908	42	76.20	Hard granite.	Small lower heading. Hand work.
May, 1908	100	51.58	50' soft granite, 50' hard granite.	Small lower heading. Machine work.

June, 1908	[illegible]	4.3	[illegible] granite. [illegible]	[illegible]
July, 1908	[illegible]	[illegible]	[illegible] granite. [illegible]	[illegible]
Aug. 1908 [illegible] days	[illegible]	[illegible]	[illegible]	[illegible]
Sept. 1908	[illegible]		[illegible]	[illegible]
Oct. 1908	[illegible]	[illegible]	[illegible]	[illegible]

Shaft Heading, South.

Oct. 1908	[illegible]	[illegible]	Hard, blocky granite.	[illegible]

Note—Lower Heading [illegible] small [illegible] main tunnel.

In April, 1908, a [illegible] 118 cubic yards. Work was [illegible] installation.

A shaft [illegible] in the clear and [illegible] was sunk at Station 30.05 during July, August and September, 1908, through [illegible] bearing granite, at an average speed [illegible] per foot, including equipment. Power to [illegible] Shaft is taken from the North Portal power house [illegible] 2200 volts. The shaft is equipped with a [illegible] single drum hoist, operating a single-deck cage, a No. [illegible] Nash blower for ventilation, a high-head Byron Jackson 3 stage [illegible] pump for drainage, three Sullivan rock drills with steel [illegible] A 30'x40' corrugated iron blacksmith shop and a [illegible] corrugated iron hoist house have been erected and fully equipped.

From the Shaft, the tunnel headings have been extended in both directions; the south heading, for a distance of 100 feet, is in a blocky granite, requiring a small heading, and extensive timbering of the full tunnel section. The South heading November 10, was [illegible] feet from the Shaft. The North heading has been driven [illegible] feet from the shaft.

South Portal.

The South Portal of the Elizabeth Tunnel was opened by hand on September 20, 1907, breaking 12 feet 4 inches by [illegible] feet [illegible] inches, using 8"x8" timbers, with a four piece arched cap. Piston machines were installed, using a second hand Giant Air Compressor, driven by a second hand marine engine. This temporary equipment was replaced, and about April 10th the following equipment was put into commission; power being supplied from the same source as at the North portal:

2—520 feet Franklin Compressors, belt driven from 2 Westinghouse 100 h. p. Induction Motors

1—150 H. P. Fairbanks-Morse Motor Generator Set to furnish current for the lights and locomotive.
3—Westinghouse 33,000-400 V. 125-K. W. Transformers, together with the necessary intermediate transformers, auto starters, switch-boards and meters, for handling both the underground and surface work.
1—No. 5½ Root rotary pressure blower of 4,000 cu. ft. capacity, for ventilation, belt driven by
1—30 H. P. Fairbanks-Morse D. C. Motor.

In August a small machine shop equipment was placed in one side of the power house, consisting of one small lathe, 1 drill press, 1 circular saw, 1 emery wheel and 1 power hack-saw. These handle all the necessary shop work around the plant.

The tunnel was supplied with the following:

1—2400-pound Draw-bar pull Baldwin-Westinghouse Mine Locomotive.
15—40 foot Koppel side dump mine cars.
4—Model 6 Leyner Air Drills, together with all necessary receivers, water tanks, manifolds, hose, etc., to carry on the work.

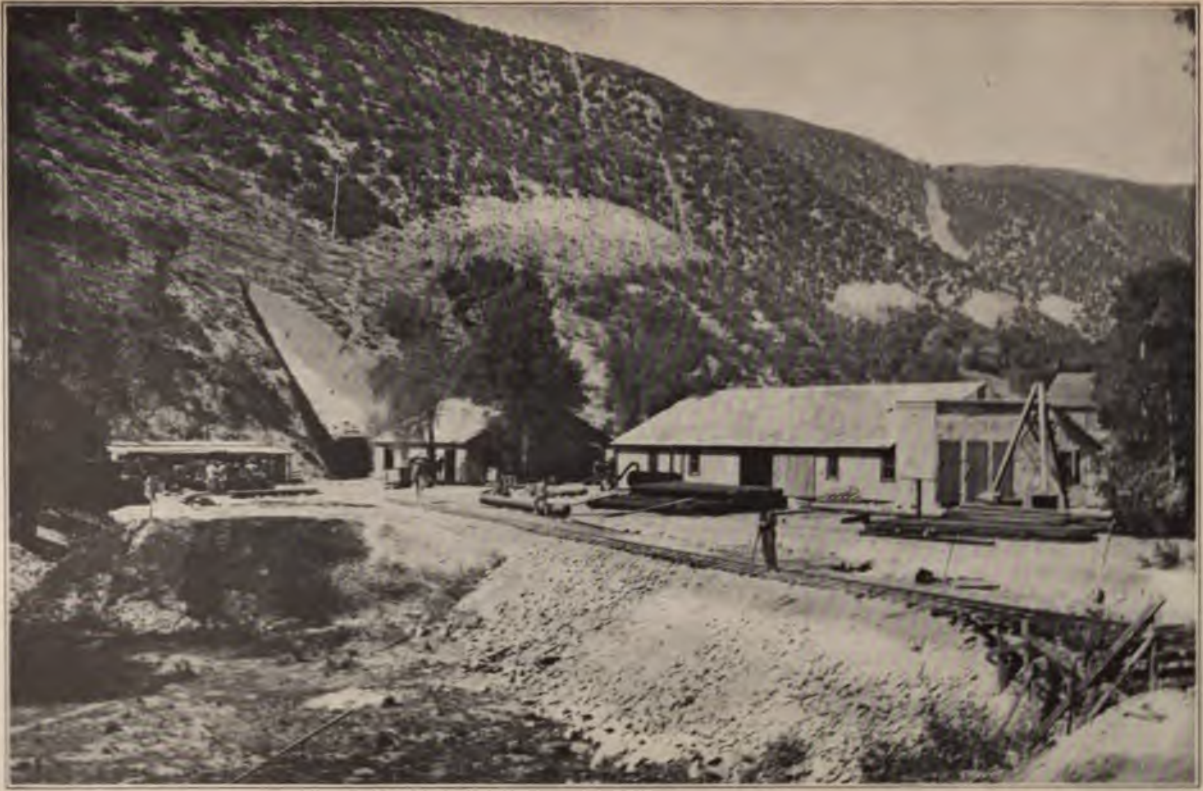
During the year there was laid underground:

2600 feet of 18″ ventilating pipe.
2600 feet of 6″ O. D. air pipe.
2600 feet of 2″ water pipe.
2600 feet of 35-pound rail track.
2000 feet of No. 000 trolley.

Electric lights, extension cables, switches, tool boxes and other necesary equipment were placed, and the track and trolley extended 700 feet on the dump.

The following buildings were erected on the ground:

1 Power House, galvanized iron, 40′x80′.
1 Blacksmith shop, galvanized iron, 40′x40′.
1 Warehouse and Office, galvanized iron, 20′x60′.
1 Barn and Feed Room, 38′x64′.
1 Blower Room, 8′x18′.
1 Mess House, 40′x64′.
3 Bunk-houses, 20′x68′.
1 Cottage, 4 rooms.
1 Cottage, 3 rooms.
1 Hospital, 5 room, 30′x35′.



SOUTH PORTAL OF ELIZABETH TUNNEL.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

1 Oil Tank Rack, 4′x24′.
1 Powder Thawer, 3′x4′.
1 Powder Magazine (tunnel).
1 Root Cellar (half tunnel), 8′x12′.

The buildings are comfortable and in good condition, the mess-house and three bunk-houses being painted. The camp is supplied with water from a 45 foot well, lifted 67 feet by a No. 2 Gould Centrifugal pump driven by a 7½ H. P. Fairbanks-Morse D. C. Motor to an 8′x16′ circular concrete tank reservoir, from which place it is distributed through 1062 feet of 2 inch main and smaller laterals to all the buildings. A 1 inch Centrifugal pump driven by a 5 H. P., D. C. Motor forces the water into a cooling tank, from which place it passes into the circulating system of the transformers and compressors. Fire protection is given by four 2 inch plugs fitted with 400 feet of woven cotton hose.

The heading was driven from October 10, 1907 to November 1st, 1908, at the following rate and cost:

Month.	In Charge.	Excavation: Feet.	Excavation: Cost.	Timbering: Feet.	Timbering: Cost.	Misc. Cost.	Total Cost.
Oct., 1907............	Gray	72	$ 5.82	72	$5.16	$ 2.89	$13.87
Nov., 1907............	Gray	117	12.57	102	3.39	4.76	20.72
Dec., 1907............	Gray	91	21.41	75	1.39	3.92	26.72
Jan., 1908............	McLeod	85	35.57	69	2.64	12.49	50.70
Feb., 1908............	McLeod	115	27.12			7.12	34.24
Mar., 1908............	McLeod	110	29.24	32	4.20	7.80	41.24
Apr., 1908............	McLeod	156	24.94			5.01	29.95
May, 1908............	Aston	244	22.19			5.95	28.14
June, 1908............	Aston	237	23.20			8.86	32.06
July, 1908............	Aston	285	23.29			6.71	30.00
Aug., 1908............	Aston	288	26.29			8.48	34.77
Sept., 1908............	Aston	242	31.38			9.79	41.17
Oct., 1908............	Aston	466	30.00			5.78	35.78

The footage for the month of October, 1908, of 466 feet is the American record for hard rock tunnel driving, exceeding the former record, held by the Gunnison Tunnel, by 17 feet. A total of 83 sets of timber have been placed in the tunnel since it started. During the driving, no difficult problems have arisen, and no unusual conditions have been encountered. The bonus system was adopted in July, 1908, and its effect was immediately felt. The City is now able to secure first class miners and a much better grade of labor generally. The change is noticed in the footage and the workmanship shown in the tunnel. The method of driving now used is to carry the underneath heading about 8 feet high and full width, letting the arch follow about 100 feet behind, where the work on it will not interfere with the men in the heading. This method was adopted after several experiments with others, and has proved the greatest time saver of all. Several small experiments have been carried on in connection with powder, fuse and caps with varying results. There is practically no water inside, and conditions are favorable for rapid progress.

The hospital is in good shape to handle the sick or injured, and is in capable hands, having a good steward in charge and a doctor, who is located at the North Portal, about three hours distant. A few slight accidents have occured, but otherwise the health of the camp has been comparatively good. Owing to natural conditions in the canyon, it is impossible to build a sewer, but steps have been taken to improve the already fairly good sanitary conditions at once.

Division 11.—Saugus.

The Saugus Division begins at the lower Power Drop in the San Franciscquito Canyon at an elevation of 1520 feet, 9 miles north of Saugus and ends at the Point of Delivery in the San Fernando Valley, about one mile below Tunnel Station on the Southern Pacific Railroad at an elevation of 1462.8. The length is 75,837 feet of which 15,551 feet is in canal, 38,915 feet in tunnels and 21,311 feet in flumes and siphons. The total fall consumed is 57.20 feet. The topography is exceedingly rough with construction in a compact sand and gravel formation free from water.

The surveys and establishment of grades, location of reservoirs, etc., on this Division have been made with plans ever in mind for the ultimate development of electrical energy.

As explained elsewhere in this report, with 400 second feet mean flow the greatest value for power, which varies from different hours of the day and for various days of the week, could be obtained by discharging through the power houses 1,000 second feet during the hours of maximum consumption and reducing the flow correspondingly during the night hours of small demand. In order to accomplish this, a reservoir has been designed at the north end of Elizabeth Tunnel with a capacity for holding an eight day's supply of water which is more than is required but which furnishes a reserve to guard against breaks in the Aqueduct above. From this upper reservoir, called Fairmont Reservoir, the Elizabeth Tunnel has a capacity of 1,000 second feet and the power plants may be designed with this in view.

Below the power sites, in order to reduce construction costs, it is desirable to regulate the flow back to its normal of 400 second feet. This may be accomplished with the Dry Canyon Reservoir which is 14,400 feet from the lower drop in the San Francisquito Canyon. This site being off the main drainage line of the San Francisquito, and in a small valley with little drainage, is free from serious danger of silting. The point of delivery to the Dry Canyon Reservoir will be at an elevation of 1505 feet, and the grade elevation at the outlet from it will be 1500 feet, the storage capacity between these levels being about 300 acre feet. The dam will be approximately 510 feet long on top and 60 feet high and will contain about 150,000 cubic yards of earth. It is proposed to construct this dam by the hydraulic fill process, which at a cost of twenty cents per cubic yard will be $30,000. The length of the reservoir will be 4,100 feet and its use will effect a saving in cost of conduit, besides serving the purpose for which it is designed.

With the exception of the first 1200 feet which will be covered bench conduit, all of the 1,000 second feet section will be underground, being a series of tunnels through the ridges of the West Side of the Divide between the San Francisquito and the Dry Canyon. The longest tunnel is 3,180 feet. From the Reservoir to the San Fernando Valley, the route lies practically at right angles to the drainage, and cuts through ridges and crosses valleys by a succession of tunnels and siphons, with short stretches of covered conduit between tunnels. The Deadman and Soledad Canyons will be crossed by two steel siphon pipes 11 feet in diameter, 4,780 feet and 8,860 feet long respectively, with a maximum head of 250 feet. About 7,565,000 pounds of steel will be required in the construction of these two siphons. The San Fernando Tunnel at an elevation of 1465 feet is 9,100 feet in length and is the second longest on the Aqueduct. The point of delivery to the San Fernando Valley is at an elevation of 1460 feet, 190 feet above the Upper San Fernando Reservoir. This drop is available for power. There are 30 tunnels in the Saugus Division and with the exception of the San Fernando Tunnel which passes through an oil bearing region, no difficulties are expected.

Surveys for the final location, with the power scheme described in the foregoing, was begun August 1, 1907, by a party in charge of D. L. Reaburn, Assistant Engineer. A system of triangulation was extended over the entire Division. In all, 35 triangulation stations were established and the angles measured by the method of repetition, using a Berger & Sons' transit. This triangulation system furnished a rigid control for all subsequent surveying operations, including the determination of the length of the principal tunnels. A party of 3 men were occupied about 10 days in its execution.

In the San Franciscquito Canyon, the topographic features fixed the location for the Power Drop and the Diversion Point, to a choice among three different sites, ranging in elevation from 1520 to 1600 feet. A consideration of this, and other conditions, led to the conclusion to develop a belt of topography over the entire Division, having a range in elevation of about 100 feet. This work was executed by the transit and stadia method. Levels were carried along with the transit—frequent checks having been made with the primary line along the County Road. The work was plotted on a scale of 100 feet to the inch with a contour interval of five feet. All feasible routes were included in the area mapped. This work was completed about October 15, 1907 and field operations were suspended for a month, while a study for economic location and adjustment of grades was made. This study resulted in the selection of the diversion dam in the San Francisquito Canyon at an elevation of 1520 feet.

In the determination of economic grades, each foot of available head for power was estimated to be worth $13,750 and the grades adopted for each class of construction, plus the power value of the head consumed in grade is a minimum. These grades are as follows; viz: for tunnels of 1,000 second feet capacity, 1 foot in 1,000; for tunnels and covered conduit of 430 second feet capacity, 5 feet in 1,000, and for siphons 0.9 in 1,000.

The party was engaged from October 15, 1907 to January 1, 1908 in staking out line, and from January 15 to February 15 in locating power and telephone lines. On this Division, 19 miles of power lines and 20 miles of telephone line have been built. Construction work on the power and telephone line from the Edison Sub-Station at Castaic to South Portal was begun February 15 and completed about April. The organization then continued northward on line work until about September 15 when preparations were begun for tunnel construction.

The two camps in Section One have been established, roads built to the headings and a line party is engaged in the completion of the power and telephone lines on the south end of the Division. A large part of the equipment for this has been purchased. Present plans contemplate the establishment of two tunnel camps in Section 4 and the construction of a building at Saugus for Division Headquarters. The present working force on the Division is 168 men.

REPORT ON PORTLAND CEMENT PLANT BUILT BY THE CITY IN CONNECTION WITH THE CONSTRUCTION OF THE AQUEDUCT.

By E. Duryee.

In January, 1908, the site of the municipal cement factory was bare of any improvements and there was no house nearer than one mile which was available for the housing of mechanics. A farm house was rented and about 15 carpenters and laborers commenced work February 1, building bunk houses and a mess hall at the new mill town site located five miles east of Tehachapi on the Southern Pacific Railroad. Grading teams commenced grading for yard trackage at the same time to provide facilities for the unloading of machinery. The bunk houses, office building and railroad sidings were completed early in March and the numbers in the construction gang were increased. Active construction work on foundations was initiated and upon the arrival of machinery installation was begun promptly. At the present time (November first), active construction work may be said to have been in progress for eight months.

MATERIALS.

Limestone.

The City owns three limestone properties: 1. The Cuddeback ledge on a 160-acre tract purchased from John Cuddeback, three miles west of the mill; 2. The North quarry on a tract of 640 acres, five and one-half miles northwest of the mill; 3. The South quarry on a tract of 120 acres, situated six miles southwest of the mill.

During the first year, prospect work has been done on all three deposits, demonstrating that the last mentioned deposit is the largest, most uniform, and of the highest grade. This deposit has been selected for supplying limestone for the mill and a quarry has been opened on the side of a hill 800 feet above its base. An aerial tramway is being installed and will be ready for operation about the middle of December. This tramway has a carrying capacity of 30 tons per hour, and is 4,700 feet long. It will deliver limestone to a bin having a capacity of 250 tons, near the base of the hill.

A narrow guage surface railroad is being built from this bin to the cement mill, five and one-quarter miles distant. This road is also to be finished early in December. Cars and a locomotive have been purchased for equipping the railroad which will deliver rock directly to a crusher at the cement mill.

Clay.

Equipment for an aerial tramway has been purchased. This cableway is 5,800 feet long, has a capacity of 25 tons per hour and is now in operation transporting the clay already excavated, from the clay bed to the cement mill. In the rear of the mill a storage floor for a six months' supply of clay has been provided. This storage capacity will be filled by December.

COST OF PROJECT.

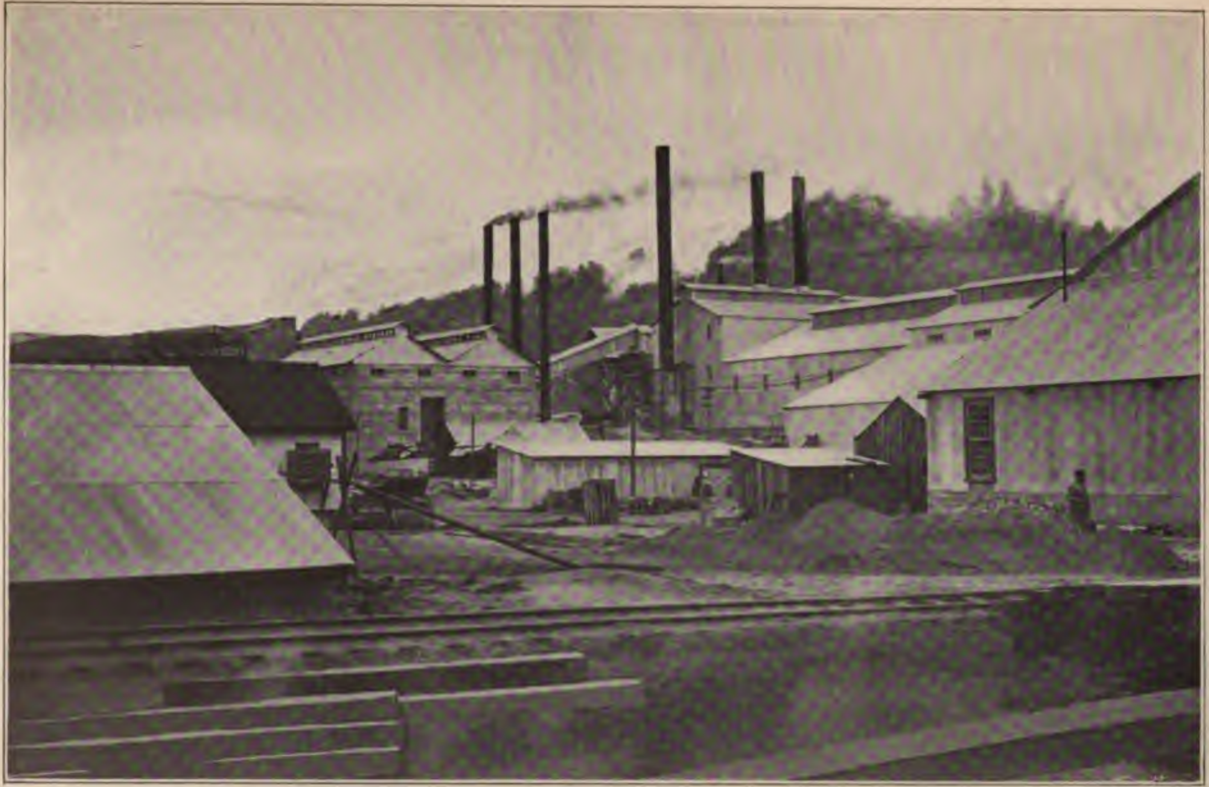
The records of material contracts show the total cost of equipment for the cement mill and power plant to date to be $266,149. This does not include aerial tramways, cement sacks, railroad siding, or narrow guage railroad to the quarry but does include some auxiliaries, such as: fuel oil storage reservoir, cement storage house, water and sewerage systems, mess hall and houses and repair shop. The total labor bills to October 1, on all the above features including both cement mill, power plant and auxiliaries amounted to $53,650.

PROCESS OF MANUFACTURE.

Cars deliver the limestone to a No. 6 McCulley crusher belt driven by a motor. The crushed rock is conveyed by a belt conveyor to a 300-ton storage bin in the dryer building. This bin discharges onto an apron conveyor which delivers by a connecting elevator to a rotary dryer, five feet in diameter by 50 feet long. From the dryer the rock is elevated and stored in steel bins above a battery of Krupp ball mills. These mills grind the rock to pass a 20 mesh screen and deliver it by screw conveyor and connecting elevator to a bin above a mixing machine.

The ball mills are operated by individual 50 H. P. motors belted to the mills which are equipped with Caldwell dust proof clutch pulleys.

Beneath the clay storage floor, previously referred to, in a pit there is a Newell clay disintegrator, motor driven. Clay passes into this machine either directly from the aerial tramway buckets by an automatic discharging arrangement or from the storage pile on the floor above. The disintegrator discharges onto a belt conveyor



CEMENT PLANT BUILT BY THE CITY OF LOS ANGELES IN CONNECTION WITH THE CONSTRUCTION OF THE AQUEDUCT.

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which delivers the clay to a rotary dryer. This is a duplicate of the rock dryer and is placed alongside the latter. The dryer delivers the dried clay to an elevator which spouts it into a bin above a rock emery mill. This 42-inch emery mill grinds the clay and it is then elevated and spouted into a bin above the proportioning machine. This machine, "Triumph" make, can be regulated to mix the ground limestone and clay in the required proportions which is approximately three parts of limestone to one of clay by weight. The proportioning is done here by volume, however. The Triumph machine delivers the materials into a paddle mixer below, thence the mixture is passed by elevator and screw conveyor to steel hoppers above a battery of Krupp tube mills. These mills are each six feet in diameter by 16 feet in length, driven by individual 75 H. P. motors. The mills are equipped with Caldwell dust proof clutch pulleys. The tube mills deliver the raw mixture to a screw conveyor connecting by elevator with another screw conveyor placed above storage bins behind the kilns. The raw mixture is delivered by screw conveyors, water jacketted and provided with changeable speed regulations into the kilns.

There are three rotary kilns each seven and one half feet in diameter by 125 feet long, equipped with Reeves variable speed devices. The kilns are operated by individual belt connected 25 horse power motors. These kilns discharge the clinker into three rotary coolers placed on a lower floor and driven from a line shaft by clutch pulleys. These coolers are of larger diameter than commonly used and are designed largely to disintegrate the clinker before it is discharged into a continuous pivoted bucket conveyor. This conveyor elevates and conveys the clinker on its upper strand above a storage floor where it is piled for aging. When ready for grinding, the clinker is delivered through spouts in the ceiling of a tunnel beneath the storage floor, into the buckets of the lower strand of the conveyor for conveyance to the finishing department. An elevator at the end of the pivotted bucket conveyor passes the clinker to a screw conveyor for distribution to bins above a battery of ball mills. After passing through the ball mills the clinker goes to a Triumph proportioning machine where the retarding plaster is added and thence to a battery of tube mills. After final grinding in these tube mills, the cement is conveyed by belt and screw conveyors to the stockhouse bins.

STATUS OF CONSTRUCTION WORK.

It is anticipated that the mill can be started during December, barring delays in the completion of the buildings. An eastern structural steel firm contracted to complete the buildings by November 15, but they have been seriously behind time and the completion of the plant and its operation are delayed by the building contractor.

The aerial tramway from the quarry to the terminal of the narrow gage railroad, as well as the narrow gage, are to be finished by December 15. The cableway from the clay bed to the mill is in operation and the steam-electric power plant is completed and ready for the development of power. The concrete fuel-oil reservoir with a capacity for a month's operation of the plant is finished. The stock-house with a capacity for storing 30,000 barrels of cement will be ready for service by November 15. The crushing, drying, grinding and burning machinery has been installed and is ready to operate as soon as the installation of conveyors, elevators, shafting and motors can be completed, but this will not be possible until the buildings are erected.

TOWNSITE OF AQUEDUCT.

The City's new town of Aqueduct is located on the Southern Pacific Railroad, five miles east of Tehachapi. Streets have been surveyed, sewer and domestic water systems have been installed and fifteen frame buildings have been erected. by the City for the housing of employees. A general merchandise store is operated by a private company. An abundant supply of excellent artesian water was secured at a depth of 120 feet. The water is pumped into a concrete serervoir of 100,000 gallons capacity, located upon a terrace above the town and mill sites, and provides adequate pressure for fire protection. Services are installed in the houses and the two largest dormitories are provided with shower baths. The demand for houses at low rentals has been urgent and will increase greatly when the plant is in operation. Injured or sick employees are cared for at a five room hospital, in charge of a steward, and well equipped for emergency operations of a minor character.

INVESTIGATIONS OF TUFA PORTLAND CEMENT.

At several points along the line of the Aqueduct, extensive deposits of tufa have been located. It was thought possible that this rock might be ground with Portland cement to reduce the cost of cement in these localities. Deposits occur at Fairmont near the Elizabeth Tunnel, at Haiwee and at the cement mill location midway between these points. Cheap power is available at each of these locations for operating crushing and grinding mills. This tufa is easily ground and is similar in analysis to the Italian tufas used in the manufacture of the old Roman cement used in the construction of the Coliseum and Roman Aqueducts.

For making the tests equal parts by weight of Portland cement and Tehachapi tufa were ground together in a laboratory ball mill to the following fineness:

	Passing 200 mesh screen.
Tufa and Portland Cement	94.45 per cent.
Original Portland Cement	84.6 per cent.

Briquettes were made with the above cements mixed with standard testing sand in the proportions of one cement to three of sand. Ten per cent of water was used in the mortar. The tests were made:

	7 Days.	28 Days.
Tufa and Portland Cement	440 lbs.	380 lbs.
Original Portland Cement	242 lbs.	260 lbs.

Briquettes were also made, using average native sand found in creek beds along the Aqueduct route. Ten per cent of water was used in the mortar. Proportion of one part cement to two of sand gave the following:

	7 Days.	28 Days.
Tufa and Portland Cement	264 lbs.	370 lbs.
Original Portland Cement	230 lbs.	260 lbs.

The setting time was quickened by the regrinding of Portland cement with tufa rock as is shown by the following:

	Initial Set.
Original Portland Cement	90 minutes.
Tufa and Portland Mixture	30 minutes.

Pats made from the Portland and Portland-tufas stood the boiling tests satisfactorily.

The neat cements showed the following tensile strengths:

	7 Days.
Original Portland Cement	395 lbs.
Tufa and Portland Cement	348 lbs.

Haiwee Tufa.

Equal parts by weight of Haiwee Tufa and Portland Cement were ground in a laboratory ball mill for eight hours with a resulting fineness of:

	Passing 200 mesh screen.
Tufa and Portland Cement	99.+ per cent.
Original Portland Cement	76.5 per cent.

Briquettes were made with the above cements and standard sand in the proportion of one cement to two of sand, with fifteen per cent of water in the case of the Tufa-Portland mortar and ten per cent in the case of the Original Portland mortar, with the following results:

	7 Days.	28 Days.
Tufa and Portland Cement	190 lbs.	300 lbs.
Original Portland Cement	220 lbs.	310 lbs.

The set can be retarded by the addition of gypsum, or plaster in small amounts of two or three per cent. The mixing of the tufa with the cement quickened the set.

	Initial Set.
Tufa and Portland Cement	6 minutes.
Original Portland Cement	55 minutes.

The pats made from the tufa and the Portland cement, and the Portland cement passed the boiling test satisfactorily.

The tests on neat briquettes gave the following results:

	7 Days.	28 Days.	% H^2O
Tufa and Portland Cement	200 lbs.	390 lbs.	26
Original Portland Cement			

Fairmont Tufa.

In the tests of Fairmont tufa it was found necessary to add three per cent of Plaster of Paris to equal parts by weight of tufa and Portland cement to retard the set.

Without adding the plaster, the cement became slow setting by remaining in air a month. The resulting fineness from grinding was:

	Passing 200 mesh screen.
Tufa and Portland Cement	Too fine to screen.
Original Portland Cement	79.6 per cent.

Briquettes (neat) gave the following tensile strengths in pounds per square inch:

Per square inch.	Days.	28 Days.	% H^2O
Tufa and Portland Cement	410 lbs.	450 lbs.	28
Original Portland Cement	460 lbs.	590 lbs.	22

ESTIMATED COST OF GRINDING TUFA-PORTLAND CEMENT.

The estimated cost of grinding the Tufa-Portland cement with electric power costing one and a quarter cents per K.W. hour, with a power requirement of 115 H.P. is as follows:

Cost of Grinding:	Per Bbl.
Power	$0.10
Miller	.02

Labor of Sacking and Loading	.05
Repairs to Mill	.05
Total Cost of Grinding, per Barrel	$0.22
Cost of Mills and Motors	$7,500.

Conclusion.

By regrinding the Portland cement with an equal weight of tufa, the original Portland cement can be made to go twice as far in construction and makes equally good mortar.

Briquettes made with standard sands in the proportion of one cement to two of sand gave the following:

	7 Days.	28 Days.	% H^2O
Tufa and Portland Cement	480 lbs.	530 lbs.	15
Original Portland Cement	110 lbs.	240 lbs.	12

The initial sets were:

Tufa and Portland Cement	6 minutes.
Original Portland Cement	45 minutes.

The boiling tests on Portland cement were satisfactory, while those on tufa and Portland cement showed contraction cracks.

TESTS OF NATURAL CEMENTS.

In the vicinity of Haiwee and the Owens Lake there are deposits of Natural Cement, samples of which were taken by Mr. Mulholland and tested in the cement laboratory. The natural rock was burned in a laboratory kiln, then ground and tested. The first tests showed a large proportion of free lime, and the briquettes crumbled in the course of 74 hours. After air slaking the cement sample it was found that the briquettes would stand up, but that they developed little or no strength in 7 or 28 days.

An alalysis of this natural cement rock gave the following:

Insoluble Residue	12.05
Alumina and Ferric Oxide	4.20
Carbonate of Lime	78.30
Carbonate of Magnesia	3.37
Total	97.92

OLD ROMAN CEMENT.

There being deposits of lime and tufa (constituents of old Roman cement) along the line of the Aqueduct, it was determined to experiment in order to see what class of cement could be made from the combination.

There was ground together, equal parts, by weight, of slaked lime and Haiwee tufa. The grinding produced a powder of which 8.5 per cent remained on a No. 100 sieve and 30.4 per cent on a No. 200 sieve. The boiling tests on neat pats resulted in marked contraction cracks and neat briquettes left in molds over night contracted to such an extent that they dropped easily from the molds in the morning. The setting time was slower. Initial set took place in four hours and thirty minutes, and the final set in twelve to sixteen hours. The briquettes were made up neat, also sand mortar in the proportions of one of slaked lime and tufa to two of sand. All briquettes were kept in moist air five days, then some were placed in water and the remainder in dry, or room atmosphere. The tensile tests resulted as follows:

Neat Briquettes:

5 days moist air, 23 days in water	250 lbs. per sq. inch.
5 days moist air, 16 days in dry air	150 lbs. per sq. inch.

Used 25% of water.

Sand Briquettes:

5 days moist air, 23 days in water	165 lbs. per sq. inch.
5 days moist air, 16 days in dry air	50 lbs. per sq. inch.

Used 15% of water.

The lime used was thoroughly water slaked and thoroughly dried by heating before being ground with the tufa.

Conclusion.

The Roman cement is greatly inferior to both Portland and Portland-tufa cements. However, it possesses hydraulic properties and might be used in localities remote from freight advantages, but where the raw materials, limestone and tufa are procurable.

The Roman cement will doubtless continue to increase in strength for long periods. It is analogous to the cement used in the construction of the Roman Colosseum and Aqueducts.

SAND TESTS.

Numerous sand deposits are to be found along the line of the Aqueduct. The only ones sampled so far are those in the vicinity of Dove Springs and along the Jawbone Division. The samples were take by Mr. Louis Mesmer, and the locations noted in reference to the Aqueduct line.

The tabulation of tests is as follows:

SAND TESTS.

SANDS FROM AQUEDUCT LINE—JAWBONE SECTION.

Sampled by Louis F. Mesmer.

Tested by E. Kent Lawrence.

	Fineness.				Tensile Tests (No. Sq. In.)					
Sample	Per Cent Passing Sieve.				Sand—3 to 1.			Per Cent	Location of Deposits.	
Number.	No. 10	No. 30	No. 50	No. 200	7 Da.	28 Da.	52 Da.	of Water.		
1	61.1	16.0	6.9	2.1	220	230	300	10	Sta. 418+00	W. of Line 0 to 1700.
2	71.4	17.4	6.4	1.0	250	290	320	12	Sta. 400+00	E. of Line 0 to 1000.
3	81.3	46.7	29.8	4.7	120	200	220	12	Sta. 122+00	N. Portal Dove Spg. Tun.
4	92.3	68.0	47.5	2.4	150	200	270	15	Sta. 124+00	Pt. N. of Line.
5	99.8	88.7	48.9	1.7	120	190	200	14	Sta. 124+00	Below Ricardo R. R. Wash.
6	71.3	21.6	7.5	0.3	240	350	330	13	Sta. 31+00	E. of Line 0 to 1500.
7	85.2	40.4	16.7	0.9	210	320	290	12	Sta. 53+91	E. of Line 0 to 2000.
8	88.9	60.6	39.1	2.5	200	260	300	14	Sta. 128+00	Pt. of Int. Dove Sp. Rd. and R. R. Rd.
9	74.5	28.0	11.7	0.7	240	300	340	12	Sta. 110+00	E. of Line 0 to 500.
10	72.0	18.2	7.4	1.6	200	270	270	11	Sta. 340+00	W. of Line 0 to 300.
11	74.0	27.4	13.0	1.6	280	260	320	11	Sta. 298+00	E. of Line 0 to 1500, W. of Line 0 to 1500.
12	86.2	51.6	33.2	6.6	110	200	220	18	Sta. 413+00	S. Port. Tunnel No. 25.
13	78.4	43.8	28.0	7.6	160	210	280	17	Sta. 400+00	N. Port. Tunnel No. 24.
14	93.8	61.8	37.0	3.0	190	250	310	14	Sta. 383+00	E. of Line 0 to 1000, W. of Line 0 to 1000.
15	92.8	17.8	7.8	2.6	200	260	400	12	Sta. 10+00	E. of Line 750 to 4500.
16	75.6	32.2	12.2	1.4	180	320	360	12	Sta. 241+50	E. of Line 0 to 1500, W. of Line 0 to 500.
17	53.2	11.4	4.6	0.8	180	280	320	12	Sta. Unknown.	
18	75.0	19.2	9.2	1.4	150	250	360	12	Sta. 70+00	E. of Line 0 to 1800.

IMPERMEABLE CONCRETES.

A series of experiments were undertaken with sands obtained along the line of the Aqueduct on the Owens River region, the object being to determine what materials might be added to the concretes to render them impermeable to water and how these additions might affect the strength of the concretes.

The samples of sand were tagged as follows:

No. 1	From Intake
No. 2	Station 38
No. 3	Station 53
No. 4	Station 75
No. 5	Station 94
No. 6	Foot of slide below Station 41

Mechanical analyses for fineness were made from No. 1 and No. 2, and the remaining samples were mixed and an analysis made of the average of Nos. 3, 4, 5 and 6. One sample of California brand of Portland cement was used in all the concrete test cylinders. Test piece "A" was made with No. 1 sand, piece "B" was made with No. 2 sand, and pieces "C," "D," "E" were made with the average of Nos. 3, 4, 5 and 6 sands. Briquettes were made from the mortar used for the permeability tests in each case in order to determine the effects of the waterproofing materials on the strength of the concretes.

The molds used for making the cylindrical sections of concrete were prepared by taking cast-iron caps for six-inch pipe, tapping out the solid cap end to reduce for three-quarter-inch nipples for connection to the water pressure pipe line. The straight sides were also channeled as indicated in the cut, with two circular channels to enable the concrete to bond strongly to the iron shell. By the use of these forms concrete cylinders six inches in diameter and six inches high were obtained. The concretes were left in the forms throughout the tests.

Fineness of Owens River Sands.

Passing ¼-inch mesh. All.	No. 1.	No. 2.	Average 3, 4, 5, 6.
Passing ¼-inch and left on No. 10 screen	43.24	7.4	5.4
Passing No. 10 and left on No. 20 screen	22.54	13.0	27.0
Passing No. 20 and left on No. 30 screen	10.85	14.9	19.2
Passing No. 30 and left on No. 40 screen	6.28	12.2	10.2
Passing No. 40 and left on No. 200 screen	16.02	50.9	33.0
Passing No. 200	1.32	2.7	2.4
Totals	100.25	100.1	97.2

"A" Concrete.

No. 1 sand, 9 pounds; dry, ground Tehachapi clay, .63 pounds; Portland cement, 3¼ pounds. The materials were mixed thoroughly dry, then 19% of water made milky with slaked lime was added and the mortar was thoroughly mixed wet. The mortar worked fat and of good consistency. The tensile strength of mortar briquettes was:

14 days	190 pounds
28 days	198 pounds
2 months	262 pounds

"B" Concrete.

No. 2 sand, 9½ pounds; dry, ground Tehachapi clay, ¼ pound; Portland cement, 3¼ pounds. The materials were mixed dry, then 1021 cubic centimeters of water containing 23 grammes of alum, equivalent to a 2½% solution of alum, was added. The water was 22% of the mortar. The mortar worked stiffer than "A" and stood some tamping in the mold before it quaked. The tensile strength per square inch of the mortar briquettes was:

14 days	176 pounds
28 days	284 pounds
2 months	296 pounds

"C" Concrete.

Average sands, 9½ pounds; dry, ground Tehachapi clay, ¼ pound; hydrated lime, .44 pound; Portland cement, 3¼ pounds. The materials were mixed dry, then 1,000 grammes of water carrying 2½% silicate of soda was added. The tensile strength per square inch of the briquettes was as follows:

14 days	134 pounds
28 days	200 pounds
2 months	236 pounds

"D" Concrete.

Average sands, 9½ pounds; stearate of lime, 2%; Portland cement, 3.2 pounds. The materials were mixed dry and 19% of water was added. The mortar was not so fat and was wetter than previous mortars containing clay. The tensile strength per square inch of the briquettes was as follows:

14 days	140 pounds
28 days	200 pounds
2 months	216 pounds

"E" Concrete.

Average sands, 9½ pounds; Portland cement, 3.17 pounds; water, 19%. No water-proofing mixture was used. The tensile strength per square inch of the briquettes was as follows:

14 days	112 pounds
28 days	206 pounds
2 months	186 pounds

Briquettes were also made with standard testing sand for comparison of tensile strengths of the preceding mortars with standard mortars. Two sets were made, the "wet" mortar being made with 19% water (the quantity used in the concretes made for the test cylinders), and the "dry" mortar being made with 10% of water.

The tensile strength per square inch, with the standard sand, was as follows:

	14 Days.	28 Days.	2 Months.
"Wet" mortar	176 lbs.	230 lbs.	302 lbs.
"Dry" mortar	240 lbs.	246 lbs.	294 lbs.

Treatment of Test Cylinders.

The test pieces were all made on the same date and under the same conditions. They were all kept damp for one month and were then connected to the Los Angeles City water main, under sixty pounds pressure, continuously for twenty-four hours. At the end of this time the "E" block showed sweating on the lower end, but all the others remained perfect. This pressure was continued for a month, continuously, without any change. During all this period all the treated mortars remained dry on the lower surfaces, but the untreated block was always damp, although not enough water to measure percolated through it.

After a month's pressure of 60 pounds, the pressure was raised by hourly stages for six hours as follows:

9:15 A. M.	60 pounds
10:15 A. M.	80 pounds
11:15 A. M.	100 pounds
Noon	A few drops from the "E" block alone
1:15 P. M.	120 pounds
2:15 P. M.	150 pounds
3:15 P. M.	(for one hour) 200 pounds

No change was noticed and none was damp with the exception of "E."

The blocks remained a month longer under 60 pounds continuous water pressure. Then the iron molds were removed from blocks "C" and "E." The concrete blocks were then weighed, and afterwards dried in an oven over a gas burner to drive off all moisture. Upon weighing, block "E" showed dampness from top to bottom, while block "C" appeared to be dry five-sixths of its height. After ignition the blocks were again weighed. The percentage of loss was 9.6 on "E" and 8.14 on "C."

Conclusions.

1. The use of any of the water-proofing materials tried renders the concretes practically impermeable.
2. For the purposes of the Los Angeles Aqueduct, the addition of small percentages of clay and slaked lime answer the purpose as well as do the other mixtures tried.
3. The addition of these materials does not affect the strength of the concrete injuriously.

TESTS OF COLTON CEMENT.

Cement being required along the line of the Aqueduct from the outset, the Board of Public Works on June 14, 1907, received proposals and awarded the contract for 30,000 barrels to the California Portland Cement Company of Colton, Cal.

The requirements were:

Fineness—Such that not more than 8 per cent by weight should remain on a standard No. 100 sieve, nor more than 25 per cent on a standard No. 200 sieve.

Time of Setting—Initial to be in not less than 30 minutes and final to be in not less than one hour and not more than ten hours.

Soundness—Pats should stand boiling test.

Boiling Test.

Tensile Strength—Neat briquettes should develop the following minimum tensile strength in pounds per square inch:

One day in air, 6 days in water	450 lbs.
One day in air, 27 days in water	550 lbs.

Sand mortar briquettes in the proportion of one cement to three of sand:

One day in air, 6 days in water	150 lbs.
One day in air, 27 days in water	225 lbs.

Of the 30,000 barrels, about 15,000 have been sampled. These have given satisfactory tests and have been accepted. Up to within the past two months the shipments have been from the old plant, but since then from the new Colton one. The product from the latter has given a smaller residue of the No. 200 sieve, as a result giving a stronger sand mortar briquette. The cement thus far delivered has been of a satisfactory quality.

REPORT OF THE QUANTITY OF THE WATER SUPPLY AVAILABLE IN THE OWENS VALLEY AS SHOWN BY FIVE YEARS OF STREAM GAGING DATA AND ON THE QUALITY OF THIS WATER AS INDICATED BY RECENT CHEMICAL AND SANITARY ANALYSES.

Chas. H. Lee.

QUANTITY.

A comprehensive study of the available water supply of the Owens Valley, appearing in the First Annual Report of the Chief Engineer, was made in the fall of 1906 with stream gaging records available from September 1, 1903, to September 30, 1906. Since that time the U. S. Geological Survey has maintained regular stations at which gage height records were kept on the following streams: Owens River at Round Valley and Charlie's Butte, and Rock, Pine, Bishop, Big Pine, Birch, Tinemaha, Taboose, Goodale, Division, Oak, Independence, Lone Pine, Tuttle, Cottonwood and Ash Creeks. The Geological Survey has also maintained stations on several creeks where discharge measurements alone were made, but at time intervals short enough, so that with the help of the hydrographs of adjacent streams, total discharges of fair value can be computed. These creeks are as follows: Baker, Eight Mile (or Sawmill), Thibaut, Symmes, Shepherd, Baers (incorrectly called Moffit), and Georges.

The U. S. Geological Survey, in co-operation with the City, is maintaining these records. The Government selects the hydrographer in charge of the work, and the Aqueduct is paying all field expenses connected therewith. The data so obtained is published as official documents of the Geological Survey.

The Chief Engineer has also detailed Mr. Charles H. Lee, Assistant Engineer, to make special hydrographic studies in Owens Valley for the City. Under his direction a station has been maintained by the City on the Owens River at Whitney Bridge since June 12, 1908, at which gage readings have been kept by a voluntary observer, H. L. Murietta; and measurements have been made on tributaries of Cottonwood Creek to determine the yield of each portion of its catchment area. During the current season the City has also carried on some special water-supply investigations, but sufficient data is not yet available to give results. These investigations consist of the following: 1. Evaporation rate from free water surface in the vicinity of Independence. 2. Precipitation between the 4000 and 6000 foot levels at the base of the Sierra. 3. Seepage losses of creeks flowing from the Sierra after leaving the mouth of canyon. 4. Fluctuation of and depth to ground water surface in the vicinity of Independence. 5. Classification with regard to surface conditions of valley lands between Charlie's Butte and Alabama Hills.

The purpose of these investigations is to obtain data for computing the yield of underground water which can be obtained from the portion of the Owens Valley from Charlie's Butte to the Alabama Hills.

The data now available for study is therefore much more extensive than that of September, 1906, and the results of greater value, since prior to January 1, 1906, gauge height records were kept on but a few of the streams south of Big Pine. Tables 1, 2, 3 and 4 give a summary of the results of Government stream gaging work since January 1, 1906.

The comparatively short period over which gagings are available in the Owens Valley renders it necessary to make a comparative study of the hydrography of adjacent drainage areas on which records have been kept longer. As pointed out in the First Annual Report, Kings River is the most favorable for such study, and with the data now available results of fair value should be obtained. Conditions to be considered are as follows: 1. The precipitation upon the crest of the Sierra Nevada Mountains, which is the common source of supply of upper Kings River and Owens Valley streams. 2. The precipitation on the high Sierra, although greater in amount than that on the San Joaquin foothills and valley, varies from season to season quite uniformly with the latter, for the reason that the bulk of the rainfall is yielded by general storms. 3. There is an exception in the case of local summer storms which occur in the high Sierra. These are occasionally of sufficient magnitude to materially increase the run-off of small Owens Valley streams, but do not equally affect Kings River on account of its larger drainage area. For example, during August, 1908, when heavy thunder storms occurred in the vicinity of Mount Whitney and northward for a period of over two weeks, the mean flow of Lone Pine Creek was 58 sec. ft. Examination of the hydrograph shows a storm run-off crest superimposed on the normal hydrograph. Omitting this crest, the mean flow is 28 sec. ft., or 50% of the actual run-off. 4. The character of the upper portion of Kings

TABLE I

Mean Monthly and Yearly Discharges Of Owens Valley Streams From Taboose Creek South

1906

Streams	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Blackrock Sp.	18.	18.	18.	18.	18.	18.	18.	18.	18.	18.	18.	18.	18.
Division Cr.	6.7	5.1	6.1	6.0	7.3	8.4	17.2	14.3	10.9	12.6	11.5	10.1	9.7
Cottonwood Cr.	6.2	8.2	10.9	24.2	114.	333.	225.	104.	42.4	15.9	13.3	12.8	75.8
Taboose Cr.	3.7	2.9	3.3	5.8	10.4	21.8	46.3	25.7	15.0	3.7	3.6	3.5	12.1
Goodale Cr.	2.0	1.0	1.0	3.5	6.3	11.2	19.0	6.4	5.9	5.6	5.3	4.3	6.0
Sawmill Cr.	3.0	2.7	3.7	3.4	4.3	7.6	16.3	12.6	9.8	6.7	5.0	5.0	6.7
Oak Cr.	6.0	7.3	7.8	11.9	28.0	69.9	140	73.5	32.2	20.5	11.8	11.3	35.
Independence	4.0	2.8	4.8	8.0	29.6	96.4	127.	54.4	22.9	12.4	6.1	5.2	31.1
Shepard Cr	2.0	2.0	2.0	9.0	26.5	62.2	104.	63.0	12.0	2.6	0.5	3.0	24.1
Baers Cr.	1.0	1.0	1.0	3.2	12.5	31.3	30.3	13.4	4.3	2.0	1.0	.5	8.5
Georges Cr	1.0	1.0	2.0	10.3	21.1	52.9	86.9	42.3	21.0	7.7	2.6	1.7	20.9
Lone Pine Cr.	3.0	2.9	3.8	7.2	28.5	73.5	129.	68.4	27.2	14	8.0	8.0	31.1
Tuttle Cr.	5.0	4.8	4.3	5.4	11.1	26.0	54.1	33.1	14.2	9.6	9.0	8.0	15.4
Ash Cr.	1.7	3.2	4.5	8.3	14.8	30.6	25.3	5.8	4.0	3.0	2.5	2.2	8.8
Total	65.3	62.9	73.2	124.	332.	843	1038	535	240	134	98.2	93.6	303

*Estimated

U.S.G.S. measurements Values fair

TABLE 2

Mean Monthly and Yearly Discharges Of Owens Valley Streams From Taboose Creek South

1907

Streams	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
Blackrock Sprgs	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*	S.F. 18.0*
Division	10.6	10.8	11.2	10.1	9.7	11.1	12.4	10.1	9.9	10.0	9.0	7.7	10.2
Cottonwood	100	10.5	12.0	56.3	115.0*	110.0	67.1	28.8	12.5	28.0	18.6	15.8	40.4
Taboose	2.3	2.3	7.3	12.0	25.0	21.0	18.0	12.0	5.0	4.2	3.6	3.2	9.5
Goodale	3.9	3.6	3.3	5.1	7.0	10.2	15.1	10.3	3.9	2.8	2.8	2.8	5.9
Sawmill	4.0*	4.0*	4.0	4.0*	6.0*	12.0*	12.0*	8.0*	6.5*	6.5*	6.0*	5.0*	6.6
Oak	10.8	10.4	12.2	18.8	26.9	42.2	57.0	32.8	20.4	14.5	13.0	13.0	22.7
Independence	5.5	3.6	4.9	14.9	26.0	62.0	70.6	35.8	16.7	6.6	7.6	6.9	21.8
Shepard	2.0	2.4	3.4	.81	14.0	26.0	37.0	21.0	4.7	5.1	4.7	2.9	11.0
Boers	1.0	1.0	3.0	7.0	9.6	12.2	11.7	4.4	1.1	1.7	2.1	1.5	4.7
Georges	2.0	2.5	5.0	11.0	17.0	19.0	28.0	13.0	4.0	5.2	3.8	2.3	9.4
Lone Pine	8.2	6.5	8.8	19.5	80.0*	45.6	61.5	39.5	11.5	19.6	16.2	8.5	23.0
Tuttle	7.4	8.5	7.4	7.3	9.0*	17.1	18.8	15.0	7.1	7.8	7.6	5.9	9.9
Ash	2.5*	2.5*	2.5*	20.0*	39.4	29.4	5.5	3.5	2.5	4.0	4.5	4.0	10.0
Total	88.2	86.5	103.0	212.0	351.0	436.0	433.0	252.0	124.0	184.0	118.0	97.5	203.0

* Estimated

U.S.G.S. Measurements. Values Fair.

TABLE 3

Mean Monthly and Yearly Discharges Of Owens Valley Streams From Taboose Creek South

1908

Streams	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
	sf	sf	sf	sf	sf	sf	sf	sf	sf	sf	sf	sf	sf
Blackrock Sprg	180	180	180	180	180	180	180	180	180	180	180	180	180
Division	70'	67	59	58	70	72	72'	77	7.7	76	77	7.6	7.1
Cottonwood	120'	125	222	58.1	622	48.5	31.2	18.7	18.0'	19.0'	16.3	14.4	27.8
Taboose	30'	23'	23'	31	49	6.0	109	82	64	45	40	5.5	51
Goodale	30'	26	26	27	44	58	73	5.0	41	33	30	3.0	3.9
Sawmill	40	40	40	45	40	35	55	5.5	3.5	3.0	4.5	4.0	4.2
Oak	100'	92	93	123	158	21.0	29.0	22.5	15.5	13.0	11.6	10.5	15.0
Independence	43	24	34	74	157	215	24.0	199	8.3	9.0	66	6.3	11.2
Shepard	13	13	13	26	62	154	220	21.0	96	57	26	20	74
Baers	10	00	00	12	30	40	45	40	16	14	1.2	1.0	1.9
Georges	27	19	22	53	8.0	110	180	140	8.1	60	32	30	7.0
Lone Pine	80'	77	82	113	17.4	32.0	44.0	58.0	24.0	113	7.6	63	19.6
Tuttle	50	45	50	55	6.0	10.0	14.0	15.0	12.0	80	70	7.0	8.2
Ash	40'	37	66	109	115	73	32	22	30	30	26	30	51
Total	833	768	910	149.0	184.0	209.0	244.0	220.0	140.0	113.0	95.9	91.6	142.0

'Estimated

USGS Measurements Values Fair

TABLE 4

Monthly Discharge of Owens River
At Charlies Butte
1904 & 1905

	1904		1905	
Month	Mean in Sec. Feet	Total in Acre - Feet	Mean in Sec.- Feet	Total in Acre Feet
Jan.	309	18980	402	24 700
Feb	321	18440	571	31 700
Mar.	341	20950	425	26 100
Apr.	214	12 700	202	12 000
May	133	8190	122	7490
June	645	38300	315	18 700
July	417	25600	257	15 790
Aug	366	22 500	49	3.010
Sept.	180	10690	59	3500
Oct.	·500	30660	141	8 660
Nov.	435	25850	241	14 310
Dec.	381	23400	314	19300
The Year	353	256600	258	185260

Computed from U.S.G.S. measurements at Citrus by adding East Side and Stevens Canal diversions

TABLE 4 (Cont.)

Monthly Discharge of Owens River at Charlies Butte

1906 & 1907

Month	1906[†]				1907[•]			
	Discharge in Sec. Feet			Total in Acre Feet	Discharge in Sec. Feet			Total in Acre Feet
	Max.	Min.	Mean		Max	Min.	Mean	
Jan	635	270	436	26800	584	440	500	30700
Feb	443	308	358	19900	572	410	493	27400
Mar.	680	277	438	26900	1350	400	646	39700
Apr	530	213	388	23100	538	170	315	18700
May	285	162	200	12300	355	164	264	16200
June	1540	224	729	43400	809	355	660	39300
July	2610[x]	1520[x]	2230[x]	137000	1710	942	1280	78600
Aug	2220[x]	730[x]	1210[x]	74400	1080	400	698	42900
Sept	700[x]	352[x]	448[x]	26700	391	278	310	18400
Oct	401	270	339	20800	731	286	460	28300
Nov	470	387	423	25200	631	505	538	32000
Dec.	560	443	510	31400	607	494	527	32400
The Year	2610	162	642	468000	1710	164	558	405000

[†] Measurement by LAA Jan. 1 – Oct. 31

[•] Measurement by U.S.G.S

[x] Computed from measurements at Citrus by adding East Side and Stevens Canal diversions

TABLE 4 (Cont.)

Monthly Discharge of Owens River at Charlies Butte

1908

Month	Discharge in Sec Feet			Total in Acre Feet
	Max	Min	Mean	
Jan	619	500	539	33100
Feb	744	513	584	33600
Mar	702	274	485	29800
Apr	255	66	145	8630
May	66	56	581	3570
June	89	36	569	3390
July	304	89	188	11600
Aug	605	102	274	16800
Sept	264	77	173	10300
Oct	390	227	298	18300
Nov	413	390	397	23600
Dec	474	346	409	25100
The Year	744	36	300	218000

Measurements by U.S.G.S.

River catchment area and that of Owens Valley streams is similar, but the lower portion of the former is quite different, being more or less heavily timbered and favorable to slow run-off and loss by evaporation and transpiration.

Rainfall and run-off are both studied by seasons, September 1 to August 31, it being assumed that the rainfall will for all practical purposes, appear in the run-off during the same period. The use of the calendar year as a run-off period is open to objection, since the autumn rains are sometimes large enough to affect the stream flow appreciably, as, for instance, During September and October, 1904, when 40% of the season's precipitation (1904-5) occurred. The mean run-off of Kings River for the calendar year 1904 was 2586 sec. ft., while for the season 1903-4 it was only 2012 sec. ft. The use of the calendar year would have made the run-off year 1904 slightly above normal, while the season 1903-4 is 25% below normal. The danger in using the calendar year for run-off with a seasonal rainfall year is thus apparent.

Rainfall records in the Kings River catchment area are meager. The best available are 36 seasons at Merced, elevation 173 ft.; 27 seasons at Fresno, elevation 293 ft.; 19 seasons at Sanger, elevation 371 ft.; 20 seasons at Visalia, elevation 334 ft., and 12 seasons at Summerdale, elevation 5270 ft.; this last, as well as Merced, being in the Merced River catchment area. As but two of these records extend back over the whole period for which stream gagings are available, namely, Merced and Fresno, it was necessary to use records at other stations for the period 1879 to 1884, and those at La Grange, Modesto and 2nd Garrotte were chosen. Table 5 gives the observed mean rainfall at each station, the computed long-term mean rainfall based on the 36 season record at Merced, and each season's rainfall expressed as a per cent of the long-term mean rainfall for all seasons during which run-off data is available on Kings River. The mean of the percentages at these base stations is assumed to represent the seasonal variations in precipitation for the whole Kings River catchment area and Owens Valley drainage as well, since Merced and Summerdale are about opposite the head of Owens River and the other stations are well distributed southward. The actual precipitation upon various portions of the west slope of the Sierra has been the subject of considerable study during the past few years. The best available information is probably that contained on the map of California showing the isohyetose lines (lines of equal mean seasonal rainfall) of the California Water and Forest Association as amended by Edwin Duryea, Jr., member Am. Soc. C. E., in 1907. By taking the proportions of the

TABLE 5

Seasonal Rainfall as % of Mean Rainfall for Seasons of Stream Gaging Records on Kings River

1879-1884 (5 Years)

Rainfall Base Stations	Merced	2nd Garrotte	La Grange	Modesto	Fresno	Average % for each Year from all Base Stations
Observed Mean Rainfall No. of Years	10.77" 35 Yrs.	32.48" 20 Yrs.	16.55" 28 Yrs	10.65" 36 Yrs.	10.11" 26 Yrs	
Deduced Long-term Mean No. of Years		37.33" 35 Yrs.			9.74" 35 Yrs.	
Year	Year's Rainfall as % of Long-term Mean Rainfall					
1879-80	110.4%	*110.4%	117.3%	121.0%	*110.4%	114.0%
1880-81	107.7	*107.7	91.4	84.0	*107.7	99.7
1881-82	73.8	*73.8	82.0	62.3	71.0	76.2
1882-83	91.1	*77.3	96.5	94.2	95.7	91.0
1883-84	205.2	141.0	161.2	120.9	194.1	162.5

1895-1908 (13 Years.)

Rainfall Base Stations	Merced	Summerdale	Fresno	Sangers	Visalia	Average % for each Year from all Base Stations
Observed Mean Rainfall No. of Years	10.77" 35 Yrs	55.42" 11 Yrs.	10.11" 26 Yrs.	11.16" 18 Yrs.	10.21" 19 Yrs.	
Deduced Long-term Mean No. of Years		52.5" 35 Yrs.	9.74" 35 Yrs.	10.37" 35 Yrs.	8.85" 35 Yrs.	
Year	Year's Rainfall as % of Long-term Mean Rainfall.					
1895-96	114.7%	— %	88.1%	90.9%	76.6%	92.6%
1896-97	105.5	101.8	104.3	117.5	117.0	109.2
1897-98	53.5	56.0	50.7	64.2	56.4	56.2
1898-99	72.6	75.8	82.0	89.6	94.0	82.8
1899-00	104.6	94.4	105.5	108.7	101.8	103.0
1900-01	106.0	162.7	116.3	142.4	133.4	132.2
1901-02	82.7	87.4	63.1	62.6	81.5	75.5
1902-03	110.3	95.0	87.3	69.3	78.4	88.1
1903-04	77.6	94.8	82.5	86.6	69.8	82.1
1904-05	122.5	95.0	124.0	132.6	119.0	118.6
1805-06	164.9	161.6	138.7	171.5	143.8	156.0
1906-07	152.0	136.7	111.4	153.6	122.7	135.3
1907-08	78.0	61.0	78.0	71.0	—	72.0

*Record filled in from other stations.

catchment area lying between various isohyetose lines and supplying these as weights to the corresponding rainfall, Mr. Duryea arrives at an average rainfall over the whole Kings River catchment area of 27.2 inches. By applying to this the mean percentages of Table 5, the average rainfall in inches over the whole area for any one season can be computed.

Run-off data for Kings River is quite extensive. California State Engineering Department records extend over the seasons 1879-80 to 1883-84, and U. S. Geological Survey records from 1895-6 to date. The mean flow for 18 seasons at Red Mountain gaging station is 2630 sec. ft. (The calendar year mean is 2500 sec. ft.) Column 2 of Table 6 gives the discharge of Kings River expressed as a percent of the 18 season mean for each season of available record.

From these data the relation of run-off to rainfall for each season has been computed, using the drainage area of 1742 square miles as published by the U. S. Geological Survey. A glance at Table 6, column 4, will show that the run-off factor is not constant for all seasons, varying from .49 to .97 during the 18 seasons of record. There are several reasons for this, but, in general, the variation in the ratio is caused by the variation in total amount and in time distribution of the season's precipitation. For the purpose of showing this, Table 6 has been prepared from data already mentioned. Column 2 gives the season's run-off expressed as a percent of the 18 seasons mean; column 3 the season's rainfall expressed as a percent of the 35 seasons' mean; column 4 the ratio of run-off to rainfall (run-off factor), and the remaining columns the monthly distribution of precipitation expressed as per cents of the season's total and based on the Fresno record. To facilitate comparison, the percentages in column 3 are classified as: I, 75% or less; II, 76% to 124%, inclusive; and III, 125% or greater. The run-off factors are classified: 1, less than .65; 2, .65 to .80, inclusive; and 3, greater than .80. Considering rainfall alone, Classes I, II and III represent dry, normal and wet seasons, respectively, but do not necessarily mean this with regard to the run-off as column 2 shows.

It will be noted: 1. That in seasons where these number classes are the same (e. g., I, 1; II, 2, etc.) there occurs somewhere in the neighborhood of 20% of the season's precipitation in each of two or more consecutive months of the series January to April, inclusive; or else in the neighborhood of 30% falls in two non-consecutive months of this series. 2. That in seasons where the rainfall number is greater than the run-off factor number there is but one of these months in which something near 20% falls, or else the months so favored are

TABLE 6
Tabular Study of the Run-off Factor
Kings River Catchment Area

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Season	% of Run-off to 18 Season Normal†	% of Rainfall to 35 Season Normal°	Ratio of Run-off to Rainfall	Monthly Distribution of Rainfall Expressed as % of Seasons Total *									
				Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
1879-80	105	114^{II}	.70^{2}	0	5	14	10	5	17	5	40	4	100
1880-81	98	100^{II}	.74^{2}	0	0	5	40	29	15	7	3	0	99
1881-82	78	76^{II}	.77^{2}	7	5	4	2	8	22	27	21	3	99
1882-83	67	91^{II}	.56^{1}	6	11	10	4	5	3	33	10	17	99
1883-84	174	162^{III}	.81^{3}	0	6	1	3	14	23	20	18	8	93
1895-96	94	93^{II}	.80^{2}	0	2	2	10	35	0	15	34	0	98
1896-97	110	109^{II}	75^{2}	0	12	14	9	18	25	16	3	0	97
1897-98	47	56^{I}	.60^{1}	0	24	4	10	8	23	14	0	16	99
1898-99	65	83^{II}	.58^{1}	14	0	4	5	24	0	37	5	0	89
1899-00	67	103^{II}	.49^{1}	0	20	15	11	15	0	8	12	19	100
1900-01	164	132^{III}	.93^{3}	1	3	41	3	19	21	3	5	4	100
1901-02	82	80^{II}	.78^{2}	8	4	9	2	7	40	18	11	0	99
1902-03	89	88^{I}	.76^{2}	0	5	26	6	22	8	27	6	0	100
1903-04	90	82^{II}	.83^{3}	0	0	8	3	7	31	34	15	1	99
1904-05	76	119^{I}	.49^{1}	13	26	0	10	8	7	17	4	13	100
1905-06	199	156^{III}	.97^{3}	0	0	7	3	15	16	30	7	21	99
1906-07	145	135^{III}	.81^{3}	0	0	7	29	31	19	16	6	0	98
1907-08	54	172^{I}	.56^{1}	0	14	0	13	22	23	9	10	8	99
Mean	100	103	.72										98

† 2630 Sec. ft.

° 27.2 Ins.

* Based on Merced 1879 to 1881 and Fresno 1881 to 1908

‡ Visalia missing

TABLE 7
Mean Seasonal Run-off
Typical Owens Valley Streams

Stream	1903-4		1904-5		1905-6		1906-7		1907-8		Observed 5 Season Mean Sec. Ft.	Deduced 18 Season Mean Based on Kings River Sec. Ft.
	Mean Discharge Sec. Ft.	% of deduced 18 Season Mean	Mean Discharge Sec. Ft.	% of deduced 18 Season Mean	Mean Discharge Sec. Ft.	% of deduced 18 Season Mean	Mean Discharge Sec. Ft.	% of deduced 18 Season Mean	Mean Discharge Sec. Ft.	% of deduced 18 Season Mean		
Owens River at Round Valley	258	98	239	91	328	125	382	145	266	101	295	263
Rock Creek	34	87	31	80	57	146	61	156	36	92	44	39
Bishop " ♦	122	111	108	98	176	160	124	113	90	82	124	110
Oak Creek	14*	79	12*	67	32	180	24	135	16	90	20	17.8
Independence Cr.	10*	66	10*	66	28	184	22	145	11.8	78	17	15.2
Lone Pine Cr.	8*	53	9*	59	27	178	23	151	20	131	17	15.2
Average of 18 Season Means		82		77		162		141		96		
												Observed 18 Season Mean
Kings River	2358	90	2012	76	5223	199	3820	145	1387	54	2950	2630

* Estimated by C.H. Lee. Probably low in 1903-4
♦ Includes Estimated Diversions
Run-off Season—Sept. 1 to Aug. 31

TABLE 8

Mean Monthly and Seasonal Discharge in Sec. Ft of Cottonwood Creek at USGS Station

Month	Season					Mean of 5 Seasons
	1903-4	1904-5	1905-6	1906-7	1907-8	
Sept	15*	10*	5	42.0	12.5	16.9
Oct.	9*	10*	5	16.0	28.0	13.6
Nov.	7*	10*	4	13.3	18.6	10.6
Dec.	7*	10*	5	12.4	15.8	10.0
Jan	8*	8*	6.1	10.0	12.0	8.8
Feb	8*	7*	8.2	10.5	12.5	9.2
Mar	10*	5*	10.9	12.0	22.2	12.0
Apr	20*	4*	24.2	56.3	58.1	32.5
May	40*	15*	114.0	115.0	62.2	69.2
June	80*	50*	333.0	110.0	48.5	124.3
July	50*	30*	225.0	67.1	31.2	80.1
Aug.	15*	15*	104.0	28.8	18.7	36.3
Mean	22.5	14.5	70.4	41.1	28.4	35.3
% of Observed 5 Season Mean	64	41.0	199.	116.	80	100
% of Deduced 18 Season Mean Based on Kings River	72	46.0	225	130	90	112◆

*Estimated from occasional measurements by CHLee
◆Deduced Mean = 31.5 Sec. Ft.
Run-off Season Sept. 1 to Aug. 31

TABLE 9

Summary of Results of Measurements on Cottonwood Creek Tributaries during 1908

Month	Flow of Tributaries at Stations						Measured Flow at U.S.G.S Station		
	2	3	4-(2+3)	5	6	Miscellaneous°	Mean in Sec Ft	Total in Acre Ft	% of Seasons Total *
	Mean Flow in Sec. Feet								
April	14	7	6	2.0	5	6	58	3451	16.5
May	16	11	6	18	52	6	62	3812	183
June	14	15.5	3	10	3	3	48.5	2856	136
July	12	8.5	2	4.5	15	2.5	31	1906	90
August	7	54	1	24	10	20	18.7	1160	55
Sept.	8	4.0	1	25	10	1.5	18	1071	51
Mean	12	8.6	3.2	9.6	2.8	3.5	39.4	Total 14246	Total 68
	% of Mean Monthly Flow at USGS Station								
April	24	12	10 5	34.5	85	10 5			
May	26	18	9.5	29	85	9			
June	29	32	6	21	6	6			
July	39	27	65	145	5	8			
Aug	37	29	5	13	5	11			
Sept.	45	22	5.5	14	5.5	8			
Mean	33	23	72	21	6.4	87			
	Run-off in Sec Ft. per Sq. Mi						Run-off in Sec Ft per Sq Mi		
April	18	1.5		2.8	1.4		1.4		
May	21	24		2.5	1.4		15		
June	18	33		14	0.8		1.2		
July	16	18		0.6	0 4		0.72		
Aug.	09	1.2		0.3	0.3		0.45		
Sept.	1.0	0.9		0.4	0.3		0.43		
Mean	1 55	1.85		1.34	0.78		0.95		
Drainage Areas	7.66 sm	4.63 sm	1.22 sm	7.18 sm	3.61 s.m.	17.38 sm	41.68 Sq mi		

* Total Flow Season Sept 1, 1907 - Aug 31, 1908 20,871 Ac Ft
° From Creeks below Junction of Little Cottonwood

separated by a period of light rainfall. 3. That in seasons where the reverse of the latter condition is true, in the neighborhood of 30% falls in two of these months consecutively. In other words, the occurrence of a large amount (50% or over) of the season's precipitation in the months January to April, inclusive, is favorable to a large run-off factor, especially if short intervals of time intervene between storms; whereas, precipitation, even though large, occurring during the months September to December, inclusive, and May and June, inclusive, is unfavorable.

It will also be noted that in a majority of seasons (1903-4 the only exception) the class numbers are either equal or else the rainfall number is greater. In other words, a season of large precipitation is favorable to a large run-off factor, whereas the reverse is true of a season of small precipitation. The exception noted is a season where 60% of the precipitation occurred evenly distributed through February and March, and furthermore, the run-off factor is very near the lower limit of the classification. The explanation of these observations probably lies to some extent in the fact that the evaporation rate is greater in the autumn and spring months, and also that long intervals of freedom from storm give more opportunity for evaporation. Should future data show the assumption to be true that run-off from the Owens Valley catchment area varies as does that from Kings River, the above relations afford a method of computing approximately the discharge of Owens Valley streams as far back as rainfall records exist.

There are six typical Owens Valley streams which have been chosen for comparison, whose measured flow represents actual run-off fairly well, although all are subject to more or less error due to seepage losses above measuring stations, and a few lose by diversions of unknown though constant amount. They are as follows: Owens River at Round Valley, Rock, Bishop, Oak, Independence and Lone Pine Creeks. Table 7 contains the mean seasonal discharge in second feet for each season of available record on these streams and its percent of the 18 season mean; the short term mean flow obtained by averaging these seasonal discharges; and the 18 season mean computed by comparison with Kings River run-off. An example of the latter computation is as follows: Mean flow for five seasons on Owens River is to the mean flow for the same five seasons on Kings River as the 18 season mean of Owens River is to the 18 season mean of Kings River. The table also contains the mean flow of Kings River for the same seasons and percentages of the 18 season mean. A considerable lack of uniformity is noticeable, but in general the variation is similar, as shown by comparison of the averaged percentages for

Owens Valley streams with Kings River. The non-uniformity is due to seepage losses, unavoidable inaccuracy in the stream gaging records, irrigation diversions and local summer storms. As an example of the last of these, the mean flow for the season 1907-8 of Lone Pine Creek is reduced from 20 sec. ft. to 18 sec. ft. (10%) by omitting the storm run-off during August, 1908, while that of Kings River would be reduced only 2.5%.

It may be said, therefore, in view of the data at hand, that in the Owens Valley the run-off season 1903-4 was about 15% below normal; the season 1904-5, 25% below normal; the season 1905-6, 65% above normal; the season 1906-7, 40% above normal, and the season 1907-8, about 10% below normal (omitting Lone Pine Creek). The season 1907-8 appears, therefore, to be the first one during which stream gaging data are available which approaches normal conditions. The seasons 1905-6 and 1906-7 were both well above normal, especially the former, and the seasons 1903-4 and 1904-5 below normal, especially the latter. The five season average is about 10% above the computed normal. These conclusions differ somewhat from those in the First Annual Report, due to the additional data and the change in the method of studying rainfall and run-off.

As pointed out in the First Annual Report, the 18 season Kings River record indicates that there is yet to be experienced a possible maximum run-off season 75% greater than the normal, and a minimum 55% less than normal, and a series of three seasons whose average run-off is 40% below normal. Stream gagings are therefore not available during a dry season, or series of dry seasons, such as have occurred in the last 35 years, and the comparative abundance of water in the last five seasons should not hide the fact that periods of real drouth are yet to be studied before the ultimate value of the Owens Valley water supply can be known with certainty.

With two years' additional data at hand, the study of the relation of supply and demand at Haiwee Reservoir has been extended, and a history of reservoir stages covering nearly five years is now available. The graphical method previously employed has been used and the following assumptions were made:

1. That the Aqueduct capacity from the intake to Lone Pine Creek is 700 sec. ft.; Lone Pine to Cottonwood Creek, 750 sec. ft.; Cottonwood Creek at Haiwee Reservoir, 900 sec. ft.

2. That the Aqueduct picks up all the flow of the Owens River at Charlie's Butte to its maximum capacity, and all the flow of creeks from Taboose to Ash and Black Rock Springs to its maximum capacity.

3. That the draft on Haiwee Reservoir is a continuous one of 430 sec. ft.

4. That the capacity of the Haiwee Reservoir is 64,000 ac. ft.

5. That January 1, 1904, Haiwee Reservoir contained 25,000 ac. ft., or 40% of its full capacity.

The history of critical stages of water level and general summary of events as shown by the Mass Curve is as follows:

January 1, 1904, to May 26, 1904, the reservoir slowly depleted, going dry on May 26, when the inflow was just equal to the draft. On May 27 the reservoir rapidly commenced to fill, and averaged about 45,000 ac. ft., or 70% of its full capacity, until the middle of September, 1905, when it commenced to empty rapidly. On October 7, 1905, the reservoir was emptied and the supply remained less than the draft until January 12, 1906. During this time there was an absolute deficiency of supply of 14,000 ac. ft.

On January 12, 1906, the reservoir commenced slowly to fill and continued thus until July 14, 1906, when wasting occurred at the lower spillway. This continued without interruption until March 28, 1908. The waste amounted to 145,000 ac. ft. in 1906, 177,000 ac. ft. in 1907, and 46,000 ac. ft. in 1908, or a total of 358,00 ac. ft. The reservoir commenced to deplete March 28, 1908, but did not fall below 32,000 ac. ft., or ½ capacity, prior to October 1, 1908, and probably will not during 1908, judging from past records.

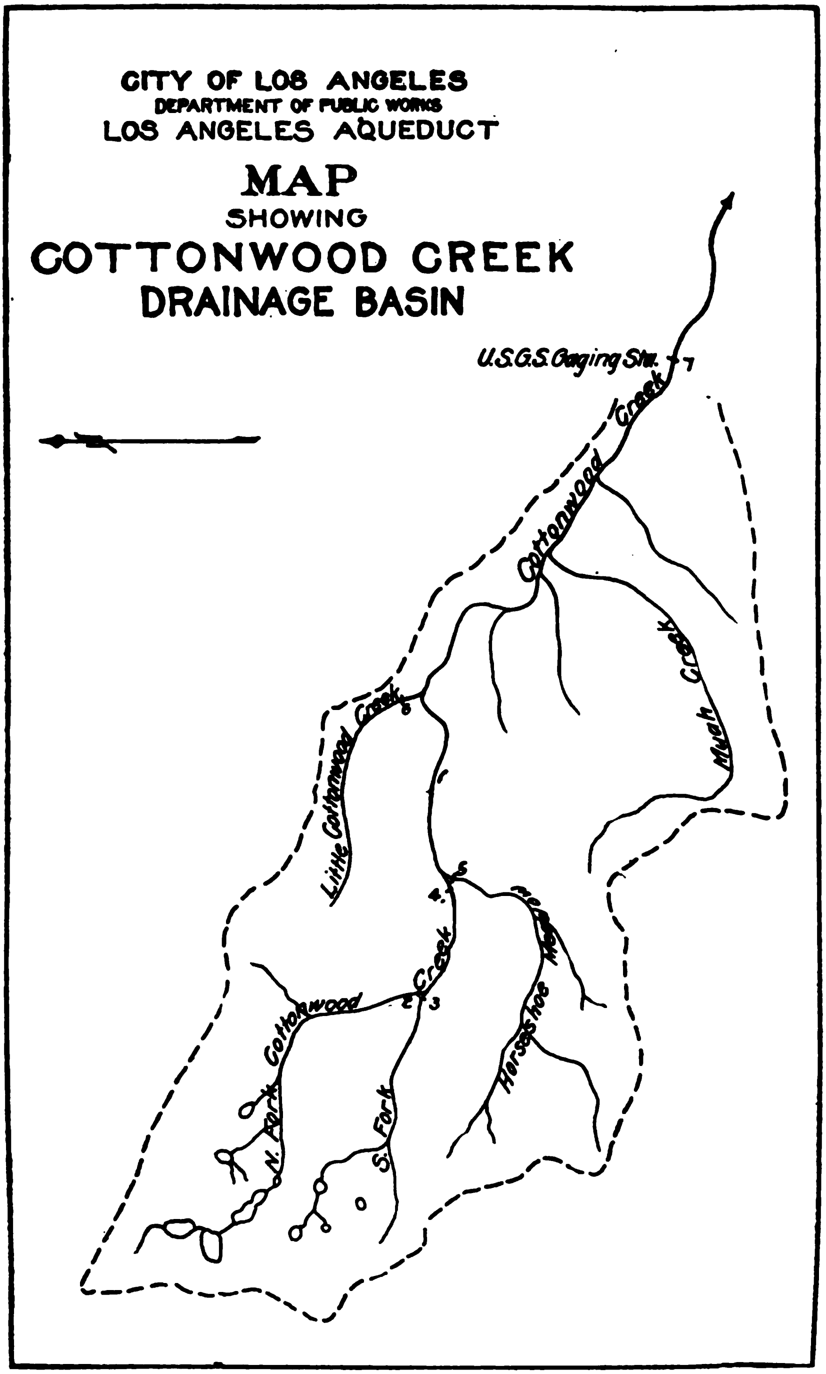
The immense waste of 358,000 ac. ft., which occurred during the 805 days from January 12, 1906, to March 28, 1908, is equivalent to a daily mean flow during the period of 220 sec. ft. The total discharge of Owens River at Round Valley during 1906 was 260,000 ac. ft., during 1907 was 254,300 ac. ft., and during January, February and March, 1908, 46,000 ac. ft., or a total of 560,000 ac. ft. As the capacity of the Long Valley Reservoir is but 260,000 ac. ft., there could have easily been retained a full reservoir for use during a possible series of dry years in the future, and still have been a waste of 202,000 ac. ft., or a continuous flow during the period of 125 sec. ft. However, the whole study is based on the assumption that the total flow of all streams from Taboose to Ash is utilized, which in practice might never be realized. This would amount to a continuous flow during the 805 days of about 220 sec. ft., and if it is assumed that only 50% of the flow of these streams was utilized during the period there would have been no waste at Haiwee Reservoir with storage at Long Valley. Should there have been no storage at Long Valley during this 805 day period, the flow of the river at Charlies Butte and Black Rock Springs alone would have supplied the draft at Haiwee

Reservoir. The fact should not be lost sight of, however, that all this wasted water is necessary for the maintenance of the 422 sec. ft. draft during a possible three year period of drouth, and therefore that long term storage in Long Valley Reservoir, or an equivalent, is absolutely necessary.

Measurements made in the Cottonwood Creek catchment area during the current season have yielded some interesting results. This area is unique among the streams draining the east slope of the Sierra in having its longest axis and drainage lines almost parallel to the trend of the range, and in this respect corresponds with that of Kern River. Another unique feature is the dissimilarity in the topographic features of various portions of the upper basin, due to the fact that the southern boundary of glaciation in the High Sierra crosses the middle of basin from east to west. The regions drained by the main creek and the South Fork are both highly glaciated and similar in topographic characteristics to the High Sierra region farther north. The more southerly portion, drained by the Horseshoe Meadow Fork, is unglaciated and has the topographic characteristics of the South Fork of Kern River, which are regarded by geologists as being those common to the whole Sierra before glaciation occurred.

The points of difference which are of importance in studying the run-off and its artificial regulation are: 1. The precipitous slopes of the one which favor the formation of large snow drifts; and the low relief, gentle slopes and large open meadows common to the other, where snow lies evenly and is fully exposed to the sunlight. 2. The natural storage afforded by great volumes of glacial drift and deep lake basins occurring on drainage lines in the one, and the almost exclusive occurrence of weathered rock in place and the shallow meadow basins of the other, with little opportunity for seepage. 2. The adaptability of the level meadows of the southern portion of the basin to artificial storage.

Precipitation is about uniform over the northern portion of the upper basin, due to its proximity to the main crest of the Sierra, but toward the south it is somewhat lighter. Due to the southern exposure and proximity to the desert, the flood crest occurs much earlier than on streams farther north and has somewhat of a double character, caused by the difference in altitude and exposures of the northern and southern portions of the basin. This is well shown by the 1908 hydrographs of typical streams. The flood crest on Lone Pine, Independence and Oak Creeks occurred about July 10, while the main Cottonwood crest occurred May 26, with a secondary one of shorter duration but greater intensity on June 1.



CITY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
LOS ANGELES AQUEDUCT

MAP
SHOWING
COTTONWOOD CREEK
DRAINAGE BASIN

The long term seasonal mean flow of Cottonwood Creek, based on that of Kings River, is about 30 sec. ft., as a glance at Table 8 will show, and the run-off season just past was about 15% below normal. The measurements made during this year in the upper basin cover a six months period, and in Table 9 will be found a summary of results. The station numbers refer to the measuring stations, which can be found by referring to the accompanying sketch of the drainage basin. The characteristics of the various tributaries are so well shown by the table that no further comment seems necessary.

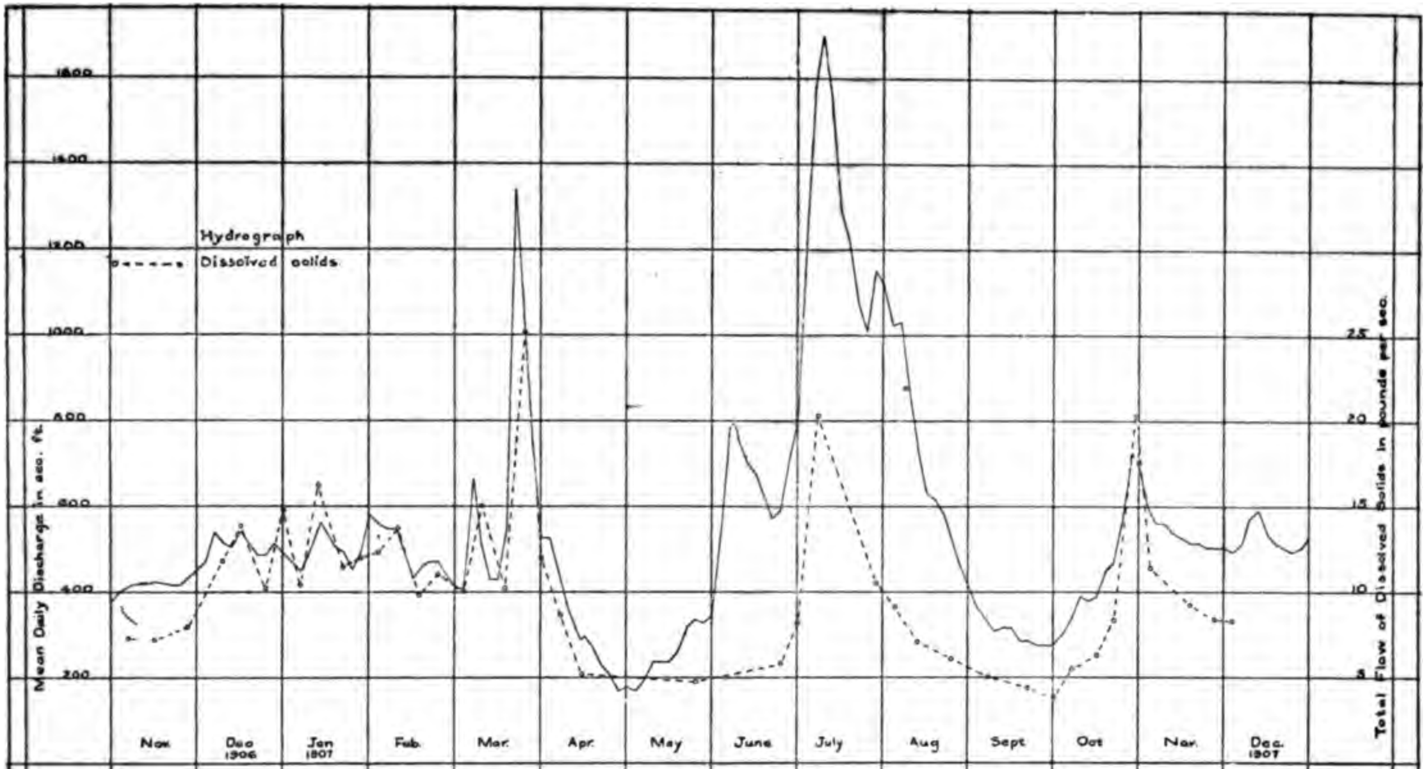
QUALITY.

Analyses of Owens River water flowing past Charlie's Butte Gaging Station, near the Los Angeles Aqueduct intake, have been made for a period of thirteen months by F. M. Eaton, chemist. Both mineral and sanitary analyses were made, the former at weekly intervals and the latter monthly.

Table 10 gives computations employed in obtaining from the original analyses the average dissolved salt contents of Owens River water at Charlie's Butte, expressed as parts in 100,000 by weight, and based on the discharge. There is also included in this table the total weight of salts passing the station during each month of the record.

The total solids in solution in the water for the entire period range from 14.6 to 50 parts per 100,000. The average dissolved salt content, based on the mean daily discharge, is 27.8 parts. If 25% of the supply passing from Haiwee Reservoir is derived from the flood flow of small streams which will be picked up by the Aqueduct below the intake, the amount of soluble salts in the resulting mixture will be at least 20% less than this, as analysis has shown the dissolved salt content of water from these streams to be very small. With this assumption, the amount of dissolved salts in solution in water stored in Haiwee Reservoir during the period November, 1906, to December, 1907, would have been 22 parts in 100,000, or 12.9 grains per gallon. This confirms Mr. Mulholland's observation made before the results of the systematic analyses were available, namely, that the soluble salt content of water stored in Haiwee Reservoir would be about 14 grains per gallon.

Comparison with the dissolved mineral salt content of water supplies of certain cities of California using surface waters is very favorable. The San Francisco supply from Alameda Creek averages 42 parts in 100,000 of dissolved salts; the Crystal Springs Lake supply, 22; the Sacramento supply from Sacramento River, 16; Berkeley, 37.8; Bakersfield supply from Kern River, 13; proposed Santa Barbara sup-



COMPARISON OF DISCHARGE AND FLOW OF DISSOLVED SOLIDS
OWENS RIVER AT CHARLIE'S BUTTE
Nov. 1906 to Dec. 1907

DIAGRAM NO. 1.

ply from the Santa Ynez River, 76. Analysis of a sample of the water supply of the City of Los Angeles through the Elysian Park pumping plant, on September 14, 1906, shows a dissolved mineral content of 48 parts in 100,000. It thus appears that the average dissolved mineral content of Owens River water passing the Los Angeles Aqueduct intake during a year of large run-off, is much smaller than that of many of the cities of California using surface supplies.

Diagram 1 shows the relation of mean daily discharge to total dissolved salt content at the Charlie's Butte Station. The total dissolved salt content is expressed in pounds per second passing the station, and is therefore independent of any dilution or concentration caused by variation in river stage.

It is of interest to note from the diagram the source from which salts are obtained. The sharp peaks of short duration which characterize the hydrograph from December 1, 1906, to April 1, 1907, and in the latter part of October, 1907, are caused by rain storms of general extent over the floors of the Owens Valley. The prominent peak in the summer months is the result of melting snow, there being no precipitation in the valley during that period. The dotted curve, representing total dissolved salts carried by the stream, follows the hydrograph closely during the period of general precipitation, but lags far behind during the summer months. It is to be inferred, therefore, that the valley floor is incrusted with large areas of soluble salts which are leached out by storm water and appear in solution after a rain storm. The water derived from melting snows, however, is comparatively free from dissolved salts, and picks up but a small amount on its way down the valley, and that probably from the flood plane. This has an important bearing on the mineral content of waters collected in Haiwee Reservoir.

TABLE 10.

AVERAGE SALT CONTENT AND TOTAL WEIGHT OF DISSOLVED SALT, OWENS RIVER AT CHARLIE'S BUTTE.

NOVEMBER, 1906—DECEMBER, 1907.

Month	Average amount dissolved salts Parts in 100,000	Total discharge in acre feet	Product	Total weight dissolved salts in tons
1906.				
Nov.	28.26 (3)	25,000	707,000	9,640
Dec.	38.90 (4)	31,350	1,219,000	16,600
1907.				
Jan.	40.05 (4)	30,700	1,230,000	16,770
Feb.	37.75 (4)	37,400	1,411,000	19,220
Mar.	40.50 (5)	39,700	1,608,000	21,900
Apr.	31.00 (2)	18,700	580,000	7,910
May	23.20 (1)	16,200	376,000	5,130
June	16.70 (2)	39,300	656,000	8,950
July	17.10 (2)	78,600	1,346,000	18,320
Aug.	16.80 (3)	42,900	720,000	9,810
Sept.	25.70 (3)	18,400	473,000	6,440
Oct.	31.90 (4)	28,300	903,000	12,300
Nov	29.10 (3)	32,000	931,000	12,690
Total		438,550	12,160,000	165,680

Numbers in parenthesis represent number of samples averaged.

Average dissolved salt content based on discharge for period Nov., 1906, to Dec., 1907, equals 12,160,000 divided by 438,550, equals 27.8 parts per 100,000, equals 16.2 grains per gallon.

The chemical constituents of the dissolved mineral in the river water at Charlie's Butte and in the small streams flowing directly from the Sierra are shown by analyses of samples taken from the river and from Cottonwood Creek on June 23, 1907. They also show the comparative salt content of the two sources of supply.

*	Total Suspended	Solids Dissolved	Calcium	Magnesium	Sodium	Sulphate	Carbonate	Bicarbonate	Chlorine
Cottonwood Creek...	0.2	5.6	0.68	0.27	1.07	1.07	0	2.57	0.61
Owens River........	17.3	16.8	2.17	0.72	2.37	2.78	0	13.20	1.77

*Parts per 100,000.

Following are two sanitary analyses by F. M. Eaton, representing United States Geological Survey, of Owens River water collected at Charlie's Butte after the close of the flood flow period of 1907, and expressed in parts per 1,000,000:

Sample Collected.	Aug. 25, 1907.	Sept. 21, 1907.
Sediment	Sandy	Sandy
Color of Sediment	Gray	Gray
Turbidity	60	26
Color of Water	12	14
Odor, Cold	0	0
Odor, Hot	2v	2m
Total Solids:		
Suspended	82	23
Dissolved	201	251
Loss on Ignition	57	46
Nitrogen as:		
Free Ammonia	.040	.006
Albuminoid Ammonia	.070	.072
Nitrite	.001	.000
Nitrate	.010	.000
Oxygen Consumed	1.3	2.3
Chlorine	17.2	23.2
Iron	.15	.30
Alkalinity	105.0	134.1
Total Hardness	110.5	104.0

These analyses show conclusively that Owens River water compares very favorably with the water supplies of most of the cities of California, and that it is very much lower in mineral content than the water now being used in Los Angeles. They also show that the mountain streams feeding the river carry water of exceptional purity, which, when mixed with the river water, will considerably reduce its mineral content.

In closing, it may be said that the data gathered during the last two years will not materially change the conclusions arrived at in the fall of 1906 regarding the quantity or quality of the Owens Valley water supply.

ANNUAL REPORT STORE DEPT

LOS ANGELES AQUEDUCT

From November 1, 1907, to November 30, 1908

Los Angeles, Cal., December 8, 1908.

Honorable Board of Public Works, City Hall, Los Angeles, Cal.

Gentlemen:—In accordance with resolution adopted by Your Honorable Board, September 27, I beg to hand you herewith an annual report ending November 30, 1908, covering the purchase of material by the Store Department under the direction of the Board of Public Works, as outlined in your resolution.

Yours very truly,

W. R. [illegible]

STATEMENT OF PURCHASES.

Showing complete list of items and quantities of each item purchased by the Board of Public Works for use upon the Aqueduct, with average cost per unit of pound, hundred weight, ton, etc. All articles of subsistence are embraced under that general head showing the gross cost; machinery covers all items that can be construed showing the gross cost; tools, axes, hammers, saws, shovels, picks, etc., etc., by number; nails, bolts, steel, iron, hay, grain, etc., by hundred weight or ton; lumber per thousand feet; *all expendable items are reported in red.*

Class "A"—Tools, Carpenter, Blacksmith, etc.
Class "B"—Machinery, Renewals and Repairs.
Class "C"—Construction Materials and Supplies.
Class "D"—Electrical Equipment and Supplies.
Class "E"—Oil, Waste, etc.
Class "F"—Office Equipment and Furnishings.
Class "G"—Transportation Equipment and Supplies.
Class "H"—Cook and Bunk House Equipment.
Class "I"—Miscellaneous.

CLASS "A."

Tools.

Items.	Unit.	Amount.
Adzes	**1¼ Doz.**	**$15.00**
Mattocks	16½ Doz.	87.85
Bars, Crow, Tamping, etc	**34 Doz.**	**494.39**
Hoes	**2 Doz.**	**10.65**
Rakes	1 Doz.	4.72
Axes, Hand Hatchets, etc	**46⅓ Doz.**	**335.50**
Sledges	**16¾ Doz.**	**131.05**
Hammers	**197¾ Doz.**	**837.67**
Tampers, Cement	22½ Doz.	76.40
Saws, Hand	**385**	**561.74**
Forks, Pitch	**2½ Doz.**	**16.75**

Items.	Unit.		Amount.
Hooks, Hay	5		1.11
Clippers, Horse	1		1.50
Levels, Carpenter	126		171.30
Wrenches, Miscellaneous	96⅛	Doz.	913.73
Files, Miscellaneous	199	Doz.	484.08
Pincers, Pliers, etc	219		183.86
Chisels, Miscellaneous	311		109.21
Squares and Bevels, Carpenter	99		59.88
Knives, Draw	89		38.06
Augers, Braces and Bits			375.35
Sets, Saw	77		20.02
Saws, Hack, Blades, etc			437.33
Compasses and Calipers	21		11.90
Mallets, Wooden	4		2.04
Trowels	171		114.81
Poles, Pike	10		17.52
Bars, Rifle			63.25
Wedges, Steel	26,012		158.75
Diggers, Posthole	3		2.00
Plumb Bobs and Cord			71.55
Climbers, Lineman and Renewals			19.68
Screwdrivers	12	Doz.	33.31
Shears, Tinners, etc	30		40.18
Tree Pruners	2		1.18
Hooks, Bush	6		3.50
Forks, Stone	6		6.00
Forks, Coke	6		8.25
Chalk Line and Chalk			26.29
Needles, Miscellaneous	147		2.83
Saw Mandrels	1		16.00
Hocks, Cant, Carrying, etc	25		42.20
Planes, Jack	66		108.99
Rules, Pencils, etc., Carpenter			14.34
Emery, Sand Paper, Cloth, etc			148.79
Swedges and Fullers	2,242	Lbs.	314.19
Pots, Melting	28		11.22
Screw Plates	42		681.10
Sleeve, Ratchets and Drills	5		33.10
Oil Stones	37		15.45
Heading Tools	1	Set.	4.00
Blacksmith Tools, Miscellaneous			95.05
Punches, Miscellaneous	43		35.85
Bellows	3		2.65
Bolt Clippers	4		13.50
Haven Grips	7		18.95
Buffalo Grips	24		89.39
Nail Pullers	3		2.05
Grindstones	49		191.71
Shovels, Hand	417	Doz.	3,076.91
Branding Iron	8		11.60

Items.	Unit.	Amount.
Tongs, Blacksmith, Pipe, etc	267 Pr.	516.47
Anvils and Fittings		1,056.29
Screws, Jack, Lifting, etc	78	446.15
Vises	96	614.07
Tool Boxes	3	42.00
Blacksmith Sows	18	48.65
Hose Expander	1	15.00
Stepladders	7	13.47
Riveting Tools		16.29
Wheelbarrows	211	1,000.05
Buckets and Pails, Miscellaneous	85⅝ Doz.	322.95
Oilers and Miscellaneous Oil Cans	272	121.51
Oil Filters	12	369.20
Hand Lever	1	26.50
Handles, Ax, Hammer, Pick, etc	696½ Doz.	1,625.70
Jim Crows	2	30.00
Picks, Hand	162⅝ Doz.	751.17
Clevises	18	13.99
Blow Torches and Plumbers' Stoves	43	196.45
Gauges, Iron and Steel Plate	1	1.88
Gauges, Wide Spring Center	3	1.54
Gauges, Wire	1	1.87
Solder, Tools and Supplies		672.87
File Brushes	12	4.80
Transits	8	1,914.00
Levels	4	625.00
Level Rods	18	110.62
Surveying Instruments, Renewals and Repairs		276.53
Trucks	7	56.25
Skids	1	5.00
Total		$21,776.50

CLASS "B."

Machinery, Renewals and Repairs.

Items.	Unit.	Amount.
Forges and Blowers	52	$1,236.95
Ratchet Rings	15	72.00
Ratchet Head Collar	6	4.40
Chains, Miscellaneous		402.36
Shafting		534.88
Bushed Sheaves	18	33.22
Boxes	67	260.29
Collars		24.18
Oil Cups	78	35.80
Cocks, Valve, Outlet, etc		67.28
Gaskets		215.65
Bushings		68.27
Pulleys	91	404.02

Items.	Unit.	Amount.
Friction Clutch	1	36.00
Derrick Repair Parts		1,282.74
Hoist Crabs	2	30.00
Welding Tire and Axle Machine	1	162.00
Tire Shrinker	1	14.25
Concrete and Cement Making Machinery		155,360.81
Concrete and Cement Making Machinery—Renewals and Repairs		33.70
Mowing Machines	1	30.00
Mowing Machines—Renewals and Repairs		34.55
Flanges, Miscellaneous		71.13
Blasting Machinery		106.95
Band Saw		140.00
Mechanical Speeders	3	1,078.00
Well Drilling Machinery		1,296.98
Well Drilling Machinery—Renewals		92.70
Aerial Tramway		21,387.72
Traveling Crane	2	1,360.00
Miscellaneous Machinery—Renewals and Repairs		35.11
Steam Shovels		25,839.20
Steam Shovels—Renewals		979.60
Clam Shell Buckets	1	500.00
Grading Outfits		15,530.00
Scrapers		3,147.00
Scrapers—Renewals		299.11
Hay Rakes		50.00
Harrows		12.00
Plows		1,147.98
Plows—Renewals		88.79
Cultivators		12.50
Feed Grinding Machinery		72.50
Seeder		10.00
Gas Engines	9	7,048.50
Water Wheel		8,806.60
Water Wheel—Renewals		8.50
Mechanical Loader and Conveyor		6,000.00
Ventilating Fan		80.00
Pipe Elevators	2 Sets.	31.60
Dredging Machinery		4,630.00
Dredging Machinery—Renewals		440.53
Piston Rings, Springs, etc		120.80
Rachet Springs	36	4.40
Drill Sharpeners		5,564.10
Drill Sharpeners—Renewals and Repairs		809.60
Pumps, Miscellaneous	44	3,454.15
Pumps, Fittings		119.06
Valves, Check Outlet, Throttle, etc		1,012.26
Drilling Machinery		33,822.29
Pipe Cutting Machinery, Dies, etc		1,014.05

Items.	Unit.	Amount.
Gears and Pinions		498.16
Miscellaneous Boiler Supplies		14.40
Blowers		6,189.50
Gravel Conveyor Fittings		106.00
Windlass	1	25.00
Miscellaneous Engine Fittings, Renewals and Repairs		1,073.80
Shaft Cage	1	275.00
Split Boxes	5	19.64
Pins, Cotter, Fulcrum, etc		26.83
Horse Stock	1	85.00
Sprocket Wheels	7	18.14
Reducing Wheel	1	12.50
Side Rod Springs	18	7.80
Boilers	7	19,696.75
Machine Dies and Renewal Parts		262.70
Emery Wheels	9	130.80
Glasses, Water, Oil Cup, etc	18	1.80
Tapping Machine	2	75.00
Air Compressors	17	26,220.00
Air Compressors—Fittings		86.05
Cutter Heads		82.50
Letter and Figure Machine	4 Sets.	3.65
Rock Crushers		1,880.00
Chain Drive and Hoist		362.60
Hoisting Engines		1,250.00
Oil Burners		350.00
Turbine Engine		50,830.00
Saw Table		160.00
Grinder Head		31.60
Lathes		3,145.03
Shapers		747.00
Drill Presses	7	244.00
Threading Machine	1	550.00
Wedge Slide Gates	6	555.00
Locomotives, Steam		3,275.00
Wheels, Tram and Fittings		156.00
Wheels, Car	330	559.12
Axles, Car	92	143.91
Cars, Quarry	12	4,284.00
Cars, Construction	133	6,605.50
Rail Bond Compressor		76.00
Belting, Lacing, Hooks, etc		3,866.67
Blocks, Tackle, Pulley, etc	233	928.21
Magnetos	3	29.30
Whistles	4	13.60
Bells and Gongs	15	56.63
Total		$441,661.93

CLASS "C."

Construction Materials and Supplies.

Items.	Unit.	Amount.
Iron	95 Tons.	$4,425.75
Steel	80 Tons, 760 Lbs.	6,960.51
Brasses	6	71.20
Babbit	924 Lbs.	172.93
Pontoons	1	232.00
Tanks, Oil, Water, Air, etc		6,691.53
Cables		1,671.23
Pipe and Fittings, Miscallaneous		81,336.88
Casing		64,759.23
Turnbuckles	6	2.70
Air Hose and Fittings		660.13
Oil Sprinkler Supplies		11.25
Reels, Wire and Cable	7	66.50
Glue and Glue Pots		11.11
Lumber	4,596,316 Ft.	80,968.13
Grade Stakes	32,970	772.00
Ties	29,260	4,966.38
Shingles	137,455	413.45
Poles	11,078	19,243.44
Lead Pipe	123	5.78
Tile Pipe, Terra Cotta, etc		589.95
Cross Arms	4,030	928.33
Cross Arm Braces	1,050	105.25
Fire Brick	58,619	5,362.26
Fire Clay	1,600 Lbs.	12.00
Lime	228 Bbls.	285.90
Pig Lead		13.63
Sheet Lead		235.01
Cesspools		3.80
Sink and Fittings		74.22
Lavatories, Toilet Bowls and Fittings		240.49
Bath Tubs	7	113.45
Cement	20,000 Sacks.	35,000.00
Powder, Dynamite, Caps, Fuses, etc		63,796.85
Resin	20 Lbs.	2.00
Welding Compound	835 Lbs.	51.31
Zinc	80 Lbs.	9.46
Steam Pipe Covering		92.90
Rope	16,077 Lbs.	2,035.88
Nails		4,707.56
Bolts, Nuts, Washers, etc		3,292.95
Sash and Doors and Fittings		2,404.59
Asphaltum		26.65
Wall Paper		63.07

Items.	Unit.	Amount.
Paint, Varnish, Brushes, etc.		1,608.98
Tar		27.75
Rivets		124.92
Tents and Renewals		12,815.26
Wire		84,664.54
Rails		**23,035.36**
Rail Fastenings		**6,699.30**
Cattle Guards	2	150.65
Switches and Switch Stands		**6,540.25**
Rail Bonds	1,000	694.63
Corrugated Galvanized Iron		12,128.86
Window Operating Device	3	384.92
Malthoid Roofing		2,972.72
Wire Fabric		1,694.42
Wire Screen		329.91
Sole Leather	82 Lbs.	24.81
Glass, Miscellaneous		14.20
Windows, Complete	30	72.45
Window Shades	86	45.66
Padlocks	295	166.90
Fencing, Barbed, and Hog Wire		401.31
Fence Posts		36.00
Watering Troughs	11	191.50
Asbestos		17.97
Sheet Copper	228 Lbs.	61.68
Sheet Rubber	181 Lbs.	77.60
Fire Extinguishers		**291.38**
Hinges and Hasps		107.22
Building Paper		627.87
Anchor Rods and Plates	979	477.35
Rings, Miscellaneous	21	11.80
Structural Iron		50,059.48
Hardware, Miscellaneous		423.12
Sheet Tin		17.78
Borax	768 Lbs.	49.79
Mica		21.60
Ceiling Supports	221	273.47
Wire Moulding	500 Ft.	8.00
Rubber Hose and Fittings		1,911.50
Asbestos Wicking		1.20
Total		**$602,153.75**

CLASS "D."

Electrical Equipment and Supplies.

Ammeters, Wattmeters, Ampermeters	26	$2,359.30
Planimeter	2	48.95
Speed Indicators	3	50.80
Thermometers	19	22.95
Oil Meters	2	128.00
Tachometers	1	57.00

Items.	Unit.	Amount.
Search Light	2	42.50
Telephones and Renewals		844.14
Insulating Tubing		844.14
Motors	77	38,231.87
Batteries, Cells, Zinc, Coppers, etc.		465.95
Carbons	2,500	77.03
Insulator Brackets	17,750	274.78
Insulator Pins	10,365	1,485.25
Insulators	34,827	5,439.88
Conductors	500 Ft.	330.00
Lamps, Shades and Fittings		1,991.80
Transformers	35	8,999.70
Marble Panels		148.00
Switches	285	6,565.82
Standards	2	30.00
Copper Sleeves	7,100	72.90
Wiring Cord	660 Ft.	51.08
Wiring Tape	201 Lbs.	132.86
Lightning Arrestors and Protectors		225.44
Trolley Hangers	6	2.85
Trolley Wheels	6	5.10
Motor Generators	11	17,010.00
Switch Boards		898.67
Miscellaneous Electric Apparatus		11,204.51
Electric Locomotives	10	18,800.00
Stop Watch	1	7.25
Total		$116,160.73

CLASS "E."

Oil, Waste, Etc.

Items.	Unit.	Amount.
Oil and Grease, Lubricating		$3,180.00
Oil, Illuminating and Fuel	85,820 Gals.	3,760.00
Engine, Distillate	17,267 Gals.	1,318.46
Candles	84,760 Lbs.	9,129.39
Packing, Miscellaneous		861.99
Waste and Rags	4,041 Lbs.	229.82
Total		$18,479.66

CLASS "F."

Office Equipment and Furnishings.

Items.	Unit.	Amount.
Letter presses	16	$84.55
Twine	309 Lbs.	64.95
Leather Field Bags	11	17.00
Mail Bags	15	81.80

Items.	Unit.	Amount.
Stencils and Brushes	1 Set	1.50
Numbering Machines	2	23.08
Typewriters	19	1,859.75
Typewriters, Renewals and Repairs		33.35
Protectograph		30.00
Pantograph		92.50
Office Furniture, Rugs, etc.		2,734.56
Wrapping Paper and Cutter		35.64
Scissors	8 Pr.	5.95
Adding Machines	2	575.00
Adding Machines, Repairs		25.16
Template	2	2.10
Marking Pot and Brushes		3.25
Feather Dusters	30	20.00
Cuspidors	1½ Doz.	15.00
Clocks	6	21.00
Stationery and Printing		17,400.64
Total		$23,126.78

CLASS "G."

Transportation, Equipment and Supplies.

Horses	47	$7,167.50
Mules	3	375.00
Burros	15	442.50
Harness, Repairs and Renewals		3,416.91
Currycombs and Brushes	110	22.83
Horse and Mule Shoes, Nails, Calks, etc.		2,190.37
Nose Bags	16	13.25
Horse Blankets	79	173.36
Wagons, Miscellaneous		14,856.55
Saddles, Bridles, etc.		1,100.61
Automobiles	2	6,116.20
Automobiles—Renewals and Repairs		3,690.79
Motorcycles, Renewals and Repairs		1,751.01
Total		$41,316.88

CLASS "H."

Cook and Bunk House Equipment.

Lamps, Lanterns, Renewals and Repairs		$828.21
Tables	113	266.75
Barrels	413	704.57
Stoves and Stove Pipe		3,123.60
Beds, Bedding, Cots, etc.		4,529.97
Chairs	206	161.85
Canteens, Water Bags, etc.		963.33

Items.	Unit.	Amount.
Kettles	12	7.44
Mosquito Netting	7 Bolts.	3.45
Sprinkling Cans	3	1.50
Scales		**599.30**
Hay and Grain		22,462.15
Coal	302 Tons, 417 Lbs.	3,792.60
Wood	82 Cords.	425.87
Commissary, Subsistence, etc		60,391.65
Total		**$98,262.24**

CLASS "I."

Miscellaneous.

Chemist and Laboratory Supplies		$268.58
Rubber Boots and Slickers	31	151.77
Bottles	60	1.80
Drugs, Medical Supplies, Surgical Instruments		235.40
Horse Medicine		293.21
Grass Seed		319.25
Funnels	4 Doz.	4.02
Sawdust		4.50
Burlap Sacks	**70,344**	**8,460.00**
Burlap Sacks, Repairs	586	12.92
Cloth	2,240 Yds.	241.32
Clothing, Shoes, etc		417.92
Labor and Material		1,254.60
Cartage		14.50
Blacksmith Work		785.31
Weighing		32.48
Express Charges		556.73
Telephone Service		1,756.69
Telegraph Service		985.03
Stage Transportation Charges		422.47
Rentals		350.98
Advertising		937.72
Recording Fees		72.10
Certificate of Title		1,577.50
Typewriting		397.70
Books, Maps, etc		548.25
Legal Services		469.00
Photographs		152.49
Taxes		4,459.59
Water Supply		150.00
Towel Supply		39.76
Miscellaneous Merchandise		884.45
Electric Energy		3,710.76
Total		**$29,938.80**

RECAPITULATION.

Class "A"—Tools, Carpenter, Blacksmith, etc.	$ 21,776.50
Class "B"—Machinery, Renewals and Repairs	441,661.93
Class "C"—Construction Material and Supplies	602,153.75
Class "D"—Electrical Equipment and Supplies	116,160.73
Class "E"—Oil, Waste, etc.	18,479.66
Class "F"—Office Equipment and Furnishings	23,126.78
Class "G"—Transportation Equipment and Supplies	41,316.88
Class "H"—Cook and Bunk House Equipment	98,262.24
Class "I"—Miscellaneous	29,938.80
Grand Total	$1,392,877.27

REPORT OF ACCOUNTING DEPARTMENT
LOS ANGELES AQUEDUCT

CITY OF LOS ANGELES, DEPARTMENT OF PUBLIC WORKS, LOS ANGELES AQUEDUCT.

THIRD ANNUAL REPORT FOR THE YEAR ENDING NOVEMBER 30th, 1908.

Honorable Board of Public Works, City of Los Angeles:

Gentlemen:—I herewith transmit to you the Third Annual Report of the Accounting Department of the Bureau of the Los Angeles Aqueduct, for the year ending November 30, 1908.

On account of the remote and inaccessible locality in which much of the work is being prosecuted, it is not possible to obtain and assemble data necessary to admit a closing of the accounts of this department until the 15th of the month; therefore, it is only possible to present to you in this report the total expenditures to the close of October 30. The statement of cash transactions, however, is complete to date of November 30, 1908.

W. M. NELSON,
Disbursing Agent.

CASH TRANSACTIONS FOR THE YEAR ENDING NOVEMBER 30, 1908.

Cash on Hand November 30, 1907		$ 45,141.95	
Receipts.			
Bills Collectable	$ 5,965.01		
Sale of Bonds	3,092,776.61		
Bills Payable	57,166.40		
Total Receipts		3,155,908.02	
Total Receipts and Cash on Hand			$3,201,049.97
Disbursements.			
Pay Rolls	$ 542,358.93		
Material and Supplies	835,525.55		
Miscellaneous Expense Vouchers	264,968.77		
Equipment Vouchers	11,359.61		
Land Purchases	267,003.41		
Bills Payable	57,000.00		
Interest on Liabilities	225.00		
Total Disbursements		$1,978,441.27	
Cash on Hand November 30, 1908		1,222,608.70	
Total Disbursements and Cash on Hand			$3,201,049.97

Location of Cash Balance.

City Treasurer	$1,210,373.95
Disbursing Agent's Fund, Office Safe	500.00
Disbursing Agent's Fund, German American Savings Bank	11,734.75
Total	$1,222,608.70

Inasmuch as the methods of accounting and the technical terms used therewith are not known to a great majority of tax payers of the City of Los Angeles, an effort has been made in the following exhibit to place the same before the people in such a way that it may be readily understood by all interested.

Before entering into an explanation governing the accounting or matters pertaining thereto, we will mention the fact that our esteemed City Auditor, Mr. W. C. Mushet, has rendered every possible service

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to the Aqueduct in the matter of payment, etc., that he could consistently do. Realizing the fact that his is an extremely difficult position, it should be known, as stated above, that he has rendered the Aqueduct Department invaluable assistance in connection with its accounting.

(1) Authority for Expenditures.

Before a purchase or expense of any kind can be made or contracted for, it is necessary that the Board of Public Works authorize the said purchase or expense, and in all cases goods must be delivered and services rendered after the date of approval of the same by the Board of Public Works. This is modified somewhat by extreme emergencies, and in such cases, when proper explanation is given, the Board of Public Works will authorize expenditure.

(2) Bills for Material and Service.

All bills for materials, supplies, etc., or services rendered, are transmitted by sellers to the Store Department for approval; they are then transmitted to the Accounting Department for proper record, and thence to the person who received the goods or incurred the expense, for certification as to the receipt of goods or approval of services rendered. This is a well-known method of handling bills, and is practiced by railroad corporations. Contracted material is handled much in the same manner. Inasmuch as the great majority of these bills must be sent to officers or persons interested who are in the field at various distances from Los Angeles, it can readily be seen that there are occasional delays in the payment of bills.

(3) Employment of Labor.

Certain classes of employes can be given employment only under the rules of the Civil Service Commission. The number of these is too great to enumerate here, but in a general way it may be said that all assistant engineers, accountants, and classes calling for technical knowledge or skilled labor of a certain kind, are under the Civil Service Commission. These, however, form a minor part of the army of employes on the Aqueduct.

(4) Pay Rolls.

The pay rolls are outlined along the best known methods of railroad practice, and they have been surrounded by documents and reports that are deemed necessary to protect the Aqueduct from loss and also to protect its disbursing officer. These pay rolls are prepared by Construction Clerks in the field, signed by officer in charge, and transmitted to the Accounting Department for audit; thence to the Chief Engineer for approval; thence to General A. R. Chaffee, Chairman of the Advisory Committee, for approval; thence to the Board of Public Works for approval; thence to the City Auditor for examination; payment of pay rolls being made through the medium of pay check and time vouchers; the term "time voucher' being used to designate a check or draft drawn by the proper person in the field for the payment of wages for the fraction of the current month in the event of termination of services of an employe, whether by discharge or resignation.

The following financial exhibit, with its explanations, etc., is intended to convey to the tax payers of the City of Los Angeles just how much money has been received through the sale of bonds, or otherwise, and for what purposes it has been spent:

SALE OF BONDS 1905 The major part of this money was used for the purpose of preliminary investigation work, engineering, etc., the balance merging into construction work.	$1,516,166.33
SALE OF BONDS 1907-8	3,076,610.28
MISCELLANEOUS COLLECTIONS This account represents the collection of various refunds, small bills, etc., not creditable to any definite account.	1,327.88
MISCELLANEOUS RENTALS This account represents the various amounts collected for rental of land and property owned by the Aqueduct.	1,404.60
TOTAL RECEIPTS	$4,595,509.09
TOTAL EXPENDITURES	3,542,860.92
TOTAL CASH ON HAND Oct. 31, 1908, after deducting outstanding audited bills, pay checks, time vouchers, etc	$1,052,648.17

For detail of expenditures, see the following schedule:

SCHEDULE OF EXPENDITURES

GENERAL EXPENSE ACCOUNTS.

SALARIES OF GENERAL OFFICERS This account represents the salaries of general executive officers and their executive assistants, exclusive of field engineers.	$ 33,172.04
SALARIES OF CLERKS AND ATTENDANTS To this account is charged the salaries of clerks of all kinds, stenographers, copyists, etc., in general offices.	31,284.08
OFFICE SUPPLIES AND EXPENSE This account represents the cost of expense and supplies in the general offices at Los Angeles, and carries such items as rent, personal and traveling expenses, office furniture and fixtures, and all expenses of like nature.	39,263.69

STATIONERY AND PRINTING 10,395.51

This account represents the amount spent for printing of reports, annual and monthly; specifications, etc. It also carries the cost of all forms, blank books, stationery and stationery supplies used in the general offices and the field.

LEGAL EXPENSES 21,856.95

This account represents the amount spent for salaries and expense of assistant attorneys, law books, briefs, legal forms, notarial fees, cost of suits, and items of a like nature.

INSURANCE 196.67

This account represents the amount paid for premiums of fire insurance carried.

TAXES 13,116.43

This account represents the amount paid out for taxes on property owned by the city in connection with the water project, in Los Angeles and other counties.

OTHER EXPENSES 13,251.74

This account represents the amount paid out for incidental expenses that are not chargeable directly to the above mentioned accounts, the major part of it being incurred through preliminary examinations, investigations, etc., after the inception of the project.

TOTAL GENERAL EXPENSE .... $ 162,537.11

AQUEDUCT CONSTRUCTION ACCOUNTS

ENGINEERING .... $ 212,695.75

This account represents the amount spent for preliminary and final location work of the Aqueduct; also carries Los Angeles drafting room expenses.

WATER RIGHTS, REAL ESTATE AND RIGHTS OF WAY ... 1,314,170.32

This account represents the cost of lands, water rights and rights of way, all for the purpose of Aqueduct construction or for collection of water which will flow into the Aqueduct.

GRADING 43,939.03

This represents the amount paid out for excavating for cement lined conduit, whether by teams, dredge or mechanical excavators.

TUNNELS 209,985.36

This account represents the amount paid out for the driving of tunnels through which the cement lined conduit will pass.

BRIDGES, TRESTLES AND CULVERTS 608.67

This account represents the cost of bridges, trestles and culverts to support the cement lined conduit.

CONDUIT This account represents the cost of cement lined conduit through which the water is carried to Los Angeles.	15,384.03
RESERVOIRS AND HEADWORKS This account represents the cost of reservoirs constructed for the collection and storage of water to feed the cement lined conduit.	5,525.49
CROSSINGS This account represents the cost of crossings over the cement lined conduit.	5.20
TELEGRAPH AND TELEPHONE LINES This account represents the cost of telegraph and telephone lines necessary to carry on the construction of the Aqueduct.	44,839.94
ELECTRIC POWER PLANTS This account represents the cost of power plants erected at various points to supply electrical energy for Aqueduct construction, the power being generated by water pressure.	40,755.60
MISCELLANEOUS STRUCTURES This account represents the cost of miscellaneous structures used in Aqueduct construction, and consists of stores, warehouses, division offices, mess halls, bunk houses, etc.	129,514.03
ROADS AND TRAILS This account represents the cost of roads and trails necessary before the actual work of construction could begin.	88,870.82
TRANSMISSION LINES This account represents the cost of transmission lines transmitting electrical energy to the various points of construction.	83,653.45
OTHER EXPENSES This account represents items in connection with Aqueduct construction that are not chargeable to the above mentioned Aqueduct construction accounts.	20.20
TOTAL AQUEDUCT CONSTRUCTION ACCOUNTS	$2,249,967.94
EQUIPMENT EXPENSES This account represents the cost of machinery and equipment of a non-expendable nature, the term non-expendable being used to designate equipment and machinery that cannot be charged directly to any one piece of work, such as live stock, well drilling apparatus, traction engines, steam shovels, etc.	$ 64,253.98
WATER INVESTIGATIONS This account represents the cost of investigating as to the sources and supply of water that is to flow into the Aqueduct to the city of Los Angeles.	11,937.26
CEMENT INVESTIGATION This account represents the cost of investigating as to the	7,176.75

feasibility and advisability of the city owning its own cement manufacturing plant.

STORE STOCK AND MATERIAL ON HAND ACCOUNTS.... This account represents the unexpended material and supplies on hand in the various stores and under the care of accountable officers along the line of the Aqueduct.	341,858.66
CEMENT MILL CONSTRUCTION.......................... This account represents the cost of construction of the city's cement manufacturing plant near Tehachapi.	289,358.98
SUBSISTENCE COLLECTIBLE .... This account represents the net loss occasioned by the city operating its own commissary prior to the contracting of it to outside persons. This account is further treated under caption, "Items of General Interest."	15,727.16
WATER SUPPLY .... This account represents the cost of pipe lines, etc., necessary to bring pure wholesome water from available sources to the line of the Aqueduct for construction purposes and camp use.	97,063.00
WATER DEPARTMENT .... This account represents the money advanced for the Water Department of the city of Los Angeles in connection with the operation of ranches in Owens Valley, maintenance of canals, ditches, etc., necessary to hold the water rights, and things of like nature.	12,287.80
BILLS COLLECTIBLE .... This account represents money due from various persons, companies, etc., amount having been previously expended by the Aqueduct and charged against them.	12,131.39
RAILROAD CONSTRUCTION .... This account represents the amount paid for railroad facilities, such as sidings, etc., both owned and leased by the Aqueduct.	7,105.15
SUSPENSE ACCOUNT .... This account represents money that has been expended for various purposes that at this time cannot be charged against any of the above mentioned accounts, it being held in abeyance in order to determine to just which account it is to be applied.	271,455.74
TOTAL EXPENDITURES	$3,542,860.92

ITEMS OF GENERAL INTEREST

SUBSISTENCE ACCOUNT .... This account, as spoken of in the schedule of expenditures, represents the amount spent by the city in operating its own commissary. The loss was caused principally from the period	$ 95,124.32

beginning January, 1907, and ending December 31, 1907. At that time roads and trails were in course of construction, and it was a very difficult matter to get subsistence to various construction camps. These consisted mainly of gangs of men building roads and trails and building telephone and transmission lines, and construction of like nature. Emergencies frequently arose through the non-arrival of teams with subsistence, making it necessary to buy supplies throughout the Owens Valley. High prices prevailed there, making the cost of subsistence excessive. Owing to climatic conditions it was almost impossible to keep foods of a certain kind from spoiling, and great loss was occasioned by this. The fact that the buying of commissaries or anything else by the city is surrounded by rigid rules governing same, it was impossible for the Purchasing Agent to get quick action in buying goods in large quantities. This prevented the city from getting the best bargains obtainable. There were furnished 318,588 meals, which cost 29.8 cents each.

PERSONAL AND TRAVELING EXPENSES.................. 5,831.46

This account represents the amount of personal and traveling expenses of executive officers, their assistants and other employes authorized to incur such personal expenses, while engaged on business of the Aqueduct.

TEAM TRANSPORTATION 62,154.67

This account represents the amount paid for hauling by teams material and supplies, machinery, etc., to point of expenditure.

FREIGHT AND EXPRESS................................ 162,103.00

This account represents the amount paid out for railway freight and express on material, supplies and machinery, etc., to nearest point, on railway, of expenditure.

MATERIAL FOR CONSTRUCTION......................... 822,061.81

This account represents the amount paid out for material and supplies used in construction.

Correct.

E. V. HARDING,
Accountant.

W. M. NELSON,
Disbursing Agent.

Pay Rolls.

This exhibit shows the amount paid out for salaries and labor in monthly progression from June, 1907, that being the date actual construction was begun.

June, 1907	$ 9,561.59
July	11,005.31
August	12,088.33
September	14,516.37

October	16,790.24
November	21,402.55
December	22,726.96
January, 1908	26,882.80
February	29,079.09
March	40,446.52
April	46,054.27
May	50,308.82
June	54,058.64
July	60,436.81
August	68,820.27
September	84,069.88
October	131,021.70
November (approximated)	150,000.00

In October, 1908, there were 2629 employes on the Aqueduct, detailed as follows:

General Offices, Los Angeles	75
Division 2	142
Division 3	1
Division 5	145
Division 7	1,203
Division 8	349
Division 9	86
Division 10	284
Division 11	168
Cement Plant	176
	2,629

REPORT OF THE LEGAL DEPARTMENT

LOS ANGELES AQUEDUCT

For the Year Ending November 30, 1908.

December 12, 1908.

To the Honorable Board of Public Works of the City of Los Angeles:

Gentlemen:—I beg to submit the following report of work done by the Legal Department of the Aqueduct Bureau, in connection with the preparation of contracts and the acquisition of lands and rights-of-way for the Aqueduct, up to December 1, 1908.

In addition to the current office work, the Legal Department has co-operated with the City Attorney in the conduct of litigation affecting the Aqueduct, and I have prepared and appended to this report a list of the suits, giving their nature and present status.

This department has also had charge of contests before the Federal Departments, where conflicting claims or interests were encountered in the proceedings for obtaining rights-of-way for the Aqueduct, or where rights-of-way were being sought by private individuals, or corporations, in furtherance of projects which would interfere with the execution of the Aqueduct plan. A list of these controversies is also appended to this report for the information of the Board.

Very respectfully,

W. B. MATHEWS.

CONTRACTS.

The following is a complete list of the contracts prepared by the Legal Department of the Los Angeles Aqueduct, for machinery, equipment, materials, supplies and services, since the commencement of active operations on the Aqueduct, including contracts founded on specifications approved by the Board of Public Works and awards made after advertisement, and contracts made without advertisement, under the emergency provisions of the City Charter:

A. Contracts Made After Advertisement for Bids.

Spec. No.	Contractor.	Date.	Subject.	Amount.
0	J. D. Hooker & Co.	4- 1-07	Iron Pipe	$ 4,003.50
00	Frank S. Livingston	9-30-07	Well Drilling Rig	1,097.73
1	B. F. Kierulff & Co.	4-23-07	Transmission Wire	1,922.00
1	Cal. Elec. Co.	4- 6-07	Elec. App. & Mtl	717.02
1	B. F. Kierulff & Co.	4- 8-07	Oil Switches and Arc Lamps.	105.05
1	Abner Doble Co.	4-27-07	Water Wheel	2,000.00
1	General Elec. Co.	5- 8-07	Transformers	2,465.00
1	West. E. & Mfg. Co.	6-20-07	Generators and Motors	2,528.65
2	Pacific Coast Mfg. Co.	10- 5-07	Water Tube Boilers & Motors	32,594.60
2	D'Olier Eng. Co.	10-16-07	Steam Turbines, Pumps, Exciters and Switchboard	50,830.00
2	Cal. Elec. Co.	9-14-07	Transformers	287.00
3	Cal. Port. Cement Co.	6-24-07	30,000 bls. Cement at $1.75	52,500.00
4	J. D. Hooker & Co.	7-10-07	Pipe	4,510.00
5	Byron-Jackson Iron Wks.	7-18-07	12 inch Pumps	1,250.00
6	Thos. Prosser & Son	10-14-07	Tube Mills and Equipment	20,181.00
6	Vulcan Iron Works	10-14-07	Dryers Kiln Feeding Devices, Kilns and Coolers	36,385.00
6	Thos. Prosser & Son	10-14-07	Ball Mills and Equipment	27,032.10
6	Power & Mining Mch'y Co.	10-26-07	Rock Crusher, Rock and Clay Chutes	2,963.60
8	Edison Elec. Co.	10-27-07	Electrical Energy for portion of Aqueduct between Elizabeth Tunnel and Fernando Tunnel—From 1.75c to 1.30c per K.W. hr.	
10	Waite, Bailee & Co.	9-28-07	Gasoline Engine	1,750.00
10	Waite, Bailee & Co.	9-26-07	Gasoline Engine	1,700.00
11	D. C. McCan	10- 8-07	Hoist	946.80
12	Union Iron Wks. of L. A.	10- 5-07	Gearing and Boom	783.50
13	H. R. Boynton Co.	10-16-07	2-in. Iron Pipe	2,257.10
14	Pelton Water Wheel Co.	10-22-07	Water Wheel	5,760.00
14	West. Elec. & Mfg. Co.	12- 4-07	Generators, Transformers and Lightning Arresters	18,567.00
14	California Elec. Co.	11- 1-07	Switchboard Apparatus	230.00
14	J. N. Kelman	10-29-07	Oil Switches	285.00
14	Pierson, Roeding Co.	10-28-07	Electrical Supplies	7,421.72
15	W. A. Plummer	10-21-07	Cement Sacks	2,450.00
16	E. K. Wood Lbr. Co.	10-25-07	Lumber	5,194.75
17	E. K. Wood Lbr. Co.	11-14-07	Lumber	3,630.10
18	J. A. Hill	12-30-07	Hauling between Mojave and Haiwee Stations—for main road 28c per ton mile, for branch road 30c per ton mile.	

Spec. No.	Contractor.	Date.	Subject.	Amount.
19	**Llewellyn Iron Works**	12-28-07	2 Air Receivers	318.00
19	**Southwestern Sup. Co.**	1- 7-08	6-in. Casing & Flange Unions.	2,899.00
19	**Lacy Mfg. Co**	12-28-07	2000 ft. of 18-in. Steel Pipe	1,184.00
19	**Henshaw-Bulkley Co.**	1-10-08	2 Rock Crushers	1,180.00
19	**B. F. Kierulff Jr. & Co.**	12-27-07	Dump Cars, Rail, Spikes and Steel Plates	4,600.90
19	**Pierson, Roeding & Co.**	1- 6-08	Rail Bonds and Rail Bond Compressor	694.63
19	**West. Elec. & Mfg. Co.**	1-29-08	6 Transformers, 4-100 H.P. and 2-7½ H.P. Motors	8,554.20
19	**J. N. Kelman**	12-30-07	2—30,000v. Oil Switches	560.00
19	**Fairbanks, Morse & Co.**	1- 2-08	Generator Sets, Switchboards and Motors	6,820.00
20	**Calif. Hardware Co.**	11-11-07	Corrugated Iron	668.47
22	**Lacy Mfg. Co.**	12-11-07	Riveted Steel Penstock	18,529.10
23	**Alva B. Clute**	12-11-07	Teams with drivers, etc., for hauling freight. Total paid	2,332.00
26	**Machinery & Elec. Co.**	1- 6-08	Air Compressors	6,720.00
26	**Smith-Booth-Usher Co.**	1-10-08	2 Blowers	1,375.00
27	**Southern Pacific Co.**	1- 9-08	2 Switches, one near Mojave and other near Tehachapi	5,995.00
28	**Southern Pacific Co.**	4-22-08	Transportation of freight—5c per 100 lbs. to $15.40 per ton.	
29	**Webster Mfg. Co**	4-30-08	Cement Machinery	22,444.68
29	**Ernst-Wiener Co.**	5-13-08	12 Rock Quarry Cars	4,282.00
29	**B. F. Kierulff Jr. & Co.**	5- 8-08	Rails, Spikes, Bolts and Fish Plates	614.03
29	**Baker Iron Works**	5-15-08	Mechanical Speeders and Blowers	1,546.00
29	**Chas. C. Moore & Co.**	5-29-08	1 Economizer	930.00
29	**Pacific Coast Mfg. Co.**	5-12-08	1 Fuel Oil Pump	395.00
29	**The Conveying Weigher Company**	5-20-08	1 Raw Mixing Machine	660.00
29	**D'Olier Engineering Co.**	6- 3-08	2 Traveling Cranes	1,360.00
29	**Fairbanks, Morse & Co.**	6-24-08	2 Boiler Feed Pumps	1,600.00
30	**Llewellyn Iron Works**	5-20-08	Material for the construction of a power house and material for a window operating device	2,274.50
30	**Amer. Steel & Wire Co.**	5-18-08	Steel Wire Mesh	74.00
30	**Harper & Reynolds Co.**	5-29-08	Corrugated Iron, Nails and Rivets	2,242.66
31	**Marion Steam Shovel Co.**	6- 2-08	1 Steam Shovel	6,900.00
32	**Modern Steel Structural Co.**	6-13-08	Construction of steel mill building	40,800.00
35	**The Conveying Weigher Co.**	7-10-08	Proportioning machine	850.00
35	**H. W. Caldwell & Son Co.**	8-10-08	Cement Mill Machinery	10,440.00

Spec. No.	Contractor.	Date.	Subject.	Amount.
35	Union Hdw. & Metal Co.	7-31-08	Belt	562.40
35	Webster Mfg. Co.	8-12-08	Gypsum Grinder, Belt, Chain Clay Disintegrator and Repair Parts	2,720.00
36	Railway Materials Co.	9- 3-08	1 Mechanical Loader and Conveyor	6,000.00
37	Harron, Rickard & McCone	7-28-08	8 Air Compressors	11,880.00
37	Baker Iron Works	8- 3-08	8 Blowers	2,832.00
37	Smith-Booth-Usher Co.	8- 5-08	7 Air Receivers	871.00
37	Allis-Chalmers Co.	8-27-08	12 Transformers	7,680.00
37	General Elec. Co.	9-24-08	8-100 H.P. and 8-10 H.P. Induction Motors	6,934.00
37	J. N. Kelman	7-30-08	7—30,000 v. Oil Switches	2,450.00
37	Westinghouse Elec. & Mfg. Co.	8-19-08	7 Sets of Watt Meters	1,300.00
38	Carnegie Brick & Pottery Co.	7-23-08	Fire Brick	1,360.00
38	Corona Pressed Brick & Terra Cotta Co.	7-25-08	Fire Brick	2,601.85
40	Westinghouse Elec. & Mfg. Co.	11-17-08	Generators, Transformers and Lightning Arresters	7,750.00
40	Pacific Electrical Wks.	9-30-08	Copper Wire	5,251.95
40	B. F. Kierulff Jr. & Co.	10- 5-08	Wire and Line Material—wire at 16½c per lb., line material	871.25
40	Pierson, Roeding Co.	10- 5-08	Porcelain Insulators	2,190.00
40	Ira J. Francis	10- 5-08	Copper Wire	8,597.35
40	J. N. Kelman	10- 3-08	3—30,000 v. Oil Switches	980.00
40	Abner Doble Co.	10-12-08	Water Wheel	3,038.40
40	California Elec. Co.	10- 2-08	1250 Cedar Poles	4,500.00
41	Lacy Mfg. Co.	9- 4-08	Riveted Steel Pipe	7,290.83
41	Pacific Coast Mfg. Co.	9- 8-08	Steel Pipe and Couplings— Pipe Couplings, each	 10,150.28 3.95
43	A. C. St. John	9-18-08	Loading and transportation of material for portion of Aqueduct near Majove. Loading gravel, 25c per cu. yd. Hauling gravel and other material 25c per ton mile. Contract to be in force 60 days from date and continue thereafter until terminated by Board of Public Works.	
45	California Elec. Co.	11-12-08	Motors, Cedar Poles, Insulators and Cross Arms	3,682.50
45	Pierson, Roeding Co.	11- 4-08	U Bolts	44.70

Spec. No.	Contractor.	Date.	Subject.	Amount.
48	**Fulton Engine Wks**	11-12-08	1 Floating Suction Dredge	2,900.00
1-B	**Fairbanks, Morse & Co.**	11-18-07	4-in. Casing	2,647.57
1-B	**Harper & Reynolds Co.**	11-20-07	Casing, Pipe and Fittings	10,329.58
2-B	**Jno. A. Roebling's Sons Co.**	11- 5-07	Copper Wire	58,708.62
3-B	**San Pedro Lbr. Co.**	11-21-07	Lumber (O. P.)	2,328.50
4-B	**Edison Elec. Co.**	1-10-08	Porcelain Insulators, Lag Screws and Washers	2,198.41
4-B	**Pierson, Roeding Co.**	1-13-08	Cross Arms and U Bolts	624.70
4-B	**B. F. Kierulff Jr. & Co.**	1-16-08	Guy Wire	165.00
4-B	**Chas. Wier & Co.**	1- 9-08	Cedar and Redwood Poles	9,763.50
5-B	**L. W. Blinn Lbr. Co.**	1- 7-08	Lumber	3,523.18
5-B	**E. K. Wood Lbr. Co.**	1- 9-08	Window Sashes, complete, Doors and Shingles	599.95
5-B	**Calif. Hdw. Co.**	1-11-08	Corrugated Iron	236.41
6-B	**C. W. Dunning**	1- 6-08	Concrete Mixer	488.50
7-B	**J. D. Hooker Co.**	1-16-08	Steel Pipe	457.00
8-B	**Fairbanks, Morse & Co.**	1-14-08	1—6 H.P. Gasoline Engine	310.00
9-B	**Los Angeles Mfg. Co.**	1-14-08	4,000 ft. Riveted Sheet Steel Pipe dipped in Asphaltum	575.00
10-B	**Harper & Reynolds Co.**	2-21-08	4½-in. Casing	3,322.63
10-B	**H. R. Boynton Co.**	2-21-08	Casing and Fittings	6,297.85
11-B	**Stoddard-Dayton Motor Company**	2-26-08	1 Automobile	3,026.00
12-B	**R. B. Burns**	4-27-08	Meat for North and South Portals of Elizabeth Lake Tunnel at 9c per lb. 1 year. Transferred to D. J. Desmond.	
14-B	**Holbrook, Merrill & Stetson**	3-30-08	25,000 ft. of 1-in. Iron Pipe	6,287.00
15-B	**Consolidated Lbr. Co.**	4- 6-08	Lumber	2,457.00
16-B	**Giant Powder Co., Con.**	4-15-08	Dynamite, Fuse and Caps	2,998.50
17-B	**Smith-Booth, Usher & Co.**	6- 4-08	Lathes, Shapers, Drill Presses and a Pipe and Bolt Threading Machine	2,649.63
17-B	**Pacific Coast Mfg. Co.**	5-28-08	4 Power Hack Saws	84.00
17-B	**Henshaw, Bulkley & Co.**	5-29-08	Lathes, Emery Grinder and Drills	2,894.00
18-B	**J. D. Hooker & Co.**	5- 2-08	16,700 ft. 4¼-inch Casing	3,258.68
18-B	**Crane Co.**	5- 6-08	Casing and Fittings	6,156.44
20-B	**Pacific Coast Mfg. Co.**	4-30-08	Rock Drills, Drill Sharpening Machine and Steel Drills	3,829.80
22-B	**Crane Co.**	5-21-08	2-inch Iron Pipe	1,521.79

Spec. No.	Contractor.	Date.	Subject.	Amount.
23-B	Baker Iron Works	5-22-08	2,000 ft. 18-inch Riveted Steel Pipe	1,093.00
24-B	Jno. A. Roebling's Sons Co.	5-28-08	Copper Wire	2,783.57
25-B	Baker Iron Works	5-22-08	4,000 ft. 6-inch Riveted Steel Pipe	808.00
26-B	Crane Co.	5-29-08	Casing, Flange Unions, Tees, Valves and Plugs	22,643.32
27-B	The Trenton Iron Wks.	5-23-08	Wire Rope Tramway	12,500.00
28-B	Clark Bros., Mojave	6-16-08	Meat for vicinity of Mojave, at prices ranging from 6¾c to 11c per pound, 1 year. Transferred to D. J. Desmond.	
29-B	Baker Iron Works	6-12-08	1,000 ft. 10-inch Double Stovepipe, Casing and 4 Starters.	1,168.84
30-B	Crane Co.	6-13-08	1 and 2-inch Iron Screw Pipe.	3,866.11
31-B	Giant Powder Co	6-15-08	Dynamite	2,480.00
31-B	E. I. DuPont de Nemours Powder Co.	6-18-08	Black Blasting Powder	1,232.00
32-B	San Pedro Lbr. Co.	6- 8-08	Rough Oregon Pine	1,395.68
33-B	E. K. Wood Lbr. Co.	6-26-08	Rough Oregon Pine	1,132.78
34-B	Pacific Coast Mfg. Co.	6-29-08	Rails and Splice Bars	835.61
35-B	E. I. DuPont de Nemours Powder Co.	7-30-08	Black Blasting Powder	1,232.00
36-B	Montesano Lumber & Mfg. Co.	7-17-08	Rough Oregon Pine	523.32
37-B	C. W. Dunning	7-31-08	1 Concrete Mixer	700.00
38-B	Lacy Mfg. Co.	7-20-08	Double Stovepipe Casing and Starters	2,469.05
39-B	Pacific Coast Mfg. Co.	8-10-08	Drills, Sharpener and Steel Drills	3,987.70
41-B	Pacific High Explosive Co.	8- 5-08	High Explosive Powder	2,520.00
42-B	California Hdwe. Co.	8-17-08	Dynamite	2,880.00
43-B	E. K. Wood Lbr. Co.	9- 2-08	Rough Oregon Pine	2,831.70
44-B	E. K. Wood Lbr. Co.	9- 2-08	Rough Oregon Pine	2,679.10
45-B	Baker Iron Works	9- 4-08	Hoist	1,075.00
45-B	General Elec. Co	9-18-08	Induction Motor	180.00
45-B	B. F. Kierulff, Jr., & Co.	9- 4-08	Transformers, Cross Arms, Cross Arm Braces and Lag Screws	1,048.36
45-B	American Steel & Wire Co.	9-18-08	Copper Wire (per cwt.)	17.90
45-B	J. A. Roebling's Sons Co.	9-18-08	Insulator Pins	16.30
46-B	Union Hdwe. & Metal Co.	9- 4-08	Corrugated Iron and Hardware	1,096.85

Spec. No.	Contractor.	Date.	Subject.	Amount.
47-B	Pacific Coast Mfg. Co.	8-15-08	Drills, Sharpener and Steel Drills	15,946.65
48-B	H. R. Boynton Co.	9- 3-08	8 Leather Belts	974.40
49-B	Harper & Reynolds Co.	9-15-08	Rails, Splice Bars and Spikes: Rails, $26.95 per ton; splice bars and bolts, complete, 25c pr.; spikes, $2.00 per cwt. and $2.15 per cwt.; bars, 18c.	
50-B	H. R. Boynton Co.	9- 3-08	11,000 ft. 3½-in. Casing	1,740.71
51-B	H. R. Boynton Co.	9- 3-08	17,000 ft. 2-in. Iron Pipe	1,360.32
52-B	Baker Iron Works	9-17-08	11,000 ft. 12-in. Riveted Steel Pipe	4,012.00
53-B	Lacy Mfg. Co.	9-15-08	4,000 ft. 18-in. Riveted Steel Pipe	2,270.00
54-B	Norman B. Livermore	10-8-08	50 Tunnel Cars	1,500.00
55-B	Harper & Reynolds Co.	10-10-08	Gelatine Dynamite: 40%, 11½c lb.; 60%, 14½c lb.	
55-B	Union Hdwe. & Metal Co.	10-12-08	Black Blasting Powder, Fuse and Caps: Pwd., $1.40 keg 25 lbs.; fuse, $24.36 cs.; caps, $5.50 and $6.75 per M.	
59-B	Bemis Bro. Bag Co.	11-16-08	Cement Sacks	6,000.00
57-B	H. R. Boynton Co.	10-15-08	1 and 2-in. Black Iron Screw Pipe: 1-in., $3.70; 2-in., $8.08 per 100 ft.	
60-B	H. R. Boynton Co.	10-30-08	135,000 ft. 2-in. Black Iron Screw Pipe and Couplings: $7.96 per 100 ft.	
60-B	Crane Co.	11- 3-08	3½-in. and 4-in. Casing: 3½-in., $14.89 per 100 ft.; 4-in., $19.29 per 100 ft.	
61-B	Tehachapi Hay & Grain Co.	11- 2-08	200 Tons Rolled Barley	5,950.00
62-B	Fulton Engine Wks.	10-26-08	1 Self-Contained Hoist	1,350.00
63-B	Jno. A. Roebling's Sons Co.	11-10-08	Copper Wire (approx.)	14,703.53
64-B	Pierson, Roeding Co.	11- 7-08	Trolley Material	2,492.65
65-B	H. W. Johns-Manville Co.	11-10-08	Insulators	535.11
65-B	Holabird-Reynolds Co.	11- 9-08	Porcelain Knobs and Tubes	388.40
66-B	B. F. Kierulff, Jr., & Co.	11-30-08	Transformers	1,895.25
67-B	Baker Iron Works	11- 7-08	6,000 ft. 12-in. Air Pipe	2,112.00
68-B	Crane Co.	11-13-08	1-in. and 2-in. Black Iron Pipe: per 100 ft., 1-in., $3.69; 2-in., $8.05.	
68-B	H. R. Boynton Co.	11-12-08	3½-in. O. D. Casing: $15.49 per 100 ft.	

Spec. No.	Contractor.	Date.	Subject.	Amount.
69-B	Western Boiler Wks.	11- 4-08	3 Water Tanks	289.63
71-B	Pacific Coast Mfg. Co.	11-23-08	Rails, $24.95 and $26.95 per ton; splice bars, 15c and 21c per set.	
75-B	Pioneer Boiler & Machine Works	11-30-08	3 Air Receivers	364.00
76-B	California Hdwe. Co.	11-26-08	28,000 ft. Reinforcing Steel: $1.70 per 100 lbs.	
77-B	San Pedro Lbr. Co.	11- 6-08	Rough Oregon Pine	803.02
78-B	M. A. Newmark & Co.	11-19-08	Mining Candles	5,409.00
79-B	Union Hdwe. & M. Co.	11- 4-08	Dynamite: From $10.75 to $13.75 per 100 lbs.	
80-B	San Pedro Lbr. Co.	11-10-08	Lumber, Doors and Sashes	615.01
81-B	George A. Rogers	11-16-08	3 Rock Crushers	2,100.00
81-B	Livingston & Lee	11-16-08	3 Gas Engines	1,500.00
82-B	Eccles & Smith Co.	11-30-08	Drill Steel, per 100 lbs.	4.95
84-B	Consolidated Lbr. Co.	11-25-08	Oregon Pine	574.08
87-B	General Elec. Co.	11-27-08	4 Oil Brake Switches and 8 Transformers	658.00
89-B	Consolidated Lbr. Co.	11-25-08	Rough Oregon Pine	7,836.35
90-B	California Hdwr. Co.	11-25-08	R. R. Powder: $6.25 per 100 lbs.	

B. Contracts Made Without Advertisement for Bids, Under the Emergency Provisions of the City Charter.

Contractor.	Date.	Subject.	Amount.
Westinghouse Elec. & Mfg. Co.	3-21-08	2 Elec. Locomotives	$ 3,500.00
Vulcan Iron Works	4-23-08	Cement Making Machinery	625.00
Thos. Prosser & Son	10-14-07	Tube Mill Equipment	2,522.63
Harbison-Walker Refractories Co.	7-25-08	Fire Brick: 7,980, more or less, at 24c each.	
Marion Steam Shovel Co.	8-18-08	2 Shovels	12,550.00
Colorado Fuel & Iron Co.	9-16-08	Track Material: Rails, $26 per ton; angle bars, $1.60 per cwt.; bolts, $2.75 per cwt.; spikes, $2 per cwt.	
W. N. Crandall	9-18-08	To construct and complete narrow gauge steam railroad from cement mill to quarry. Constructor to receive actual cost, plus 4 per cent.	
Charles Wier & Co.	9-17-08	21,000 Redwood Ties: 20c each.	
Eccles & Smith Co.	9-18-08	R. R. Material: Tie plates, 9¾c each; switches and equipment, $275.	

Contractor.	Date.	Subject.	Amount.
A. Leschen & Sons Rope Co.	10- 1-08	Aerial Rope Tramway and Equipment	8,380.00
Vulcan Iron Works	10-10-08	1 Mine Locomotive	3,275.00
Marion Steam Shovel Co.	10- 6-08	Power Shovel and Shovel Bucket	5,300.00
Pacific Hdwr. & Steel Co.	11- 5-08	Pipe Fittings	2,384.59
The Holt Mfg. Co.	11-11-08	3 Gasoline Traction Engines and 16 Traction Engine Trucks	20,100.00
Pacific Coast Mfg. Co.	11-20-08	2 Carloads of Drill Steel and 1,600 Blank Shanks: Steel, 15c per lb.; shanks, $1.50 each.	
California Hardware Co.	11-23-08	2 Carloads Dynamite: From $10.75 per 100 lbs. to $13.75 per 100 lbs.	
Union Hdwr. & Metal Co.	11-24-08	1 Carload Dynamite: $8.65 per 100 lbs.	
D. J. Desmond	7-23-08	For the Furnishing of Meals to employees at $5 for 21 meals at all camps, except at Tehachapi, where city maintains service. Bond of $25,000 for faithful performance.	
Rae Smith, E. C. Moore and Raymond Taylor	5-13-08	To provide Medical, Surgical and Hospital Services to employees. They to receive $1.00 for each employee receiving over $40 per mo. and 50c for those receiving less than same, to be deducted monthly from wages. Bond, $2,500.	
Southern Pacific R. R. Co.	9-17-08	Constructing Red Rock Canyon Spur	Cost.
Pacific Coast Mfg. Co	11-27-08	100 pcs. Drill Steel	4,210.00
Kountze Bros. & A. B. Leach & Co.	7-10-08	$4,080,000 Bonds., int. 4½%, price par and accrued int. Option on remaining bonds in installments from 6-1-09 to 2-1-12 at par, accrued int. and premium ranging from ¼ of 1% to 1%.	
Robert Sherer & Co.	4- 2-08	Lease of Grading Outfit, 60 animals and equipment, at $12.50 per animal per month.	

Contractor.	Date.	Subject.	Amo
Southern Pacific Co	5-28-08	Modification of contract for construction of switches at Tehachapi under Spec. No. 27. Cost not to exceed	800.
American Bank Note Co	12-16-08	Classes A. B. and C.	4,400.
		Additional Bonds, each	
		Change Plates	525.
City, Clark Bros. & D. J. Desmond	7-30-08	Transfer to D. J. Desmond of city's interest in contract under Spec. 28-B.	
City, Burns & Desmond	7-30-08	Transfer to D. J. Desmond of city's interest in contract under Spec. 28-B.	

LANDS AND RIGHTS OF WAY.

The following is a complete list of purchases of lands and rights of way for the Aqueduct system:

A. Lands.

Name of Seller.	Acreage.
Aronson, Lars Erik	60.
Arna Henry	40.
Alvord Company	390.
Aguirre, Pauline	40.
Aguirre, Pauline	240.
Ablutz, Jacob (Swartout Res.)	1,080.
Baird, W. H.	400.
Benjamin, Chas. B.	15.
Baxter, Ellen Nora J.	160.
Boland Est., Thomas C.	1,280.
Carrasco, Jesus J.	160.
Collins, Chas. A.	4,720.
Crocker, F. M. and E. A.	320.
Carrasco, Jesus J. and E. H. Edwards	685.
Cuddeback, Blackley and Rose	3,000.
Cuddeback, John P.	160.
Cox Est., W. E. (entire interest)	625.25
Cox Est., W. E. (half interest)	13.
Curtis, Daniel	8.12
De Mots, Edward	160.
Densmore, F. E.	360.
Davis, Amos	6.50
Davis, Hibbard O.	60.
Duhart, Juan	47.5
Eibeshutz, A. W.	160.
Eaton, Fred. (Rickey L. & C. Co.)	22,670.

Name of Seller.	**Acreage.**
Eaton, Fred. (Rickey L. & C. Co., Long Valley)	2,684.
Eaton, Fred.	362.
Eaton, Harold	80.
Edwards, E. H. and Est. B. J. Stevens	1,400.
Forbes, P. W.	160.
Fruit World Pub. Co.	57.
Floyd, Harry C.	160.
Ferguson, Wm.	320.
Free, Clara A.	80.
Gorham, Harry M.	640.
Goodale, A. C.	160.
Gill, H. D.	160.
Griffith, G. W. E.	320.
Gruber, Samuel	80.
Hand, Mark P.	160.
Hand, Mark P.	320.
Hunter, Carrie	160.
Hamilton, H. C.	160.
Hamilton, Edward	102.
Hammett, W. A. and W. M.	320.
Henley, F. W.	15.
Hughes, Griffith O.	10.
Houle, Chas.	160.
Holland, James W.	160.
Hodder, J.	10.
Hall, L. M. (undivided half interest)	13.
Hawley, George T.	148.
Jess, Stoddard	680.
James, Margaret	640.
Jones, James	600.
Johnson, Clarence	40.
Jullien, Maurius	120.
Jones, Hugh et al	110.
Klein, Est. Jacob	640.
Kane, Isabella et al	160.
Lubkin, John H.	240.
Lubken, Augusta M. L.	160.
Lopez, Catalina	27.
Lowe, B. A.	1,008.
Lebrun, Matea	163.74
Levy, Milton	152.
Mills, Thos., and Alena and John McCord	160.
Mills, Alena	63.27
McIver, Finlay and Jessie F.	400.
Mulholland, Ivr. H.	440.
Mulholland, Irv. H.	640.
Mairs, Omie I.	1,880.
Minkler, H. L.	320.
Mitchell, W. H.	560.
Meehan and Mathews	120.

Name of Seller.	Acreage.
Martin, Ai D.	160.
McGann, Bridget	240.
Macomber A.	80.
Meehan, Frank	640.
Noble, W. M.	40.
Norviel, L. A.	320.
Norton, Willis A.	40.
National Florence Crittenton Mission	200.
Orr, Mira E.	480.
O'Neal, Frankie G.	80.
Peck, Alice (Swartout Res.)	160.
Parker, L. G. (Swartout Res.)	160.
Price, Morgan (Fairmont Res.)	10.
Porter, George K. Co.	599.01
Reynolds, Silas H.	160.
Reynolds, Silas H.	160.
Reynolds, Annie	40.
Reynolds, Elizabeth	160.
Russell, F. E.	1,600.
Rixford, Emmett	480.
Rinaldi, C. R.	171.
Reid, E. W.	320.
Robinson, Chas. W.	160.
Sandy, J. A.	40.
Siefried, Flora I.	40.
Skinner, Max M. and Harriet T	20.
Skinner, J. V.	20.
Skinner, Maggie J.	160.
Skinner, C. A.	220.
Skinner, C. A.	40.
Skinner, C. A.	120.
Stewart, J. J. and Catherine	80.
Southern Pacific Railroad Co	69.
Southern Pacific Railroad Co	40.
Stecker August	320.
Silva, Manuel	480.
Turner, John R.	1,800.
Treglown, Wm. T. est	240.
Thompson, J. W. et al	80.
Tucker, Simeon	200.
Veeder, C. E.	40.
Vaughn, David	400.
Vaughn, Lydia	80.
Watterson, M. Q.	200.
Wrinkle, S. C. F.	1,800.
White, Benj. J.	40.
Williams, W. A.	40.
Wheeler, Fred. F.	600.
Walker, Ed.	160.
White, Est. C. B.	1,440.

Name of Seller.	Acreage.
William Penn. Col. Association of Cal.	12,150.
Wolff, Katherine (Swartout Res.)	320.
Wilson, Frank M.	10.
Yandell, Ben H.	440

B. Rights of Way Over Private Lands.

American Mexican Cattle Co. (for telephone line)	00
American Mexican Cattle Co. (for pipe line)	.34
Arnold, Geo. L.	6.54
Asher and Harris	3.
Armstrong, Margaret	7.98
Booth, Hervey	1.93
Brandt, Otto A.	3.20
Bundy, Nathan P.	6.25
Bundy, Nathan P. (for pipe line)	00
Curtis, Daniel	3.06
Cuddeback, W. N.	2.98
Cuddeback, W. N.	1.80
Cuddeback, W. N.	2.00
Chapman, Wm.	6.80
Cordoba, Teodor Ortize de	3.13
Diers, Rose K.	1.50
Davis, Hibbard O.	16.88
Duhart, Juan (for tunnel)	00
Doyle, R. G.	.36
De Long, Alice	16.69
De Cou, Carolyn A.	1.95
Edson, Chas. F.	8.26
Freeman, Jacob	9.06
Gorman, J. S.	12.50
Hughes, Griffith O.	1.55
Hindley, Wm. T.	.03
Hall, Randall C.	12.43
Haskell, J. C.	7.16
Hagen, Rudolf	13.20
Hagen, Rudolf	1.64
Hillyer, James	7.34
Jordan, Gabrella	.34
Korber, Adam	1.66
Korber, Adam	5.56
Kelly and Jones	16.63
Leighton, Marie P.	6.09
Lacey Anna Maria	54.40
Lingwood, Ed.	6.92
Mills, Thos. and Alena	13.36
Mills, Alena	3.37
Morrison, Thos. H.	3.98
Morriss, Addie	6.08
McGann, Peter	2.26

Name of Seller.	Acreage.
Martin, M. D.	160.
McGlynn, Bridget	240.
Macomber, A.	80.
Meenan, Frank	640.
Nagle, W. M.	40.
Norriel, L. A.	320.
Norton, Willis A.	40.
National Florence Crittenton Mission	200.
Orr, Mira E.	480.
O'Neal, Frances E.	80.
Peck, Alice (Swartout Res.)	160.
Parker, L. A. (Swartout Res.)	160.
Price, Morgan (Fairmont Res.)	10[illegible]
Porter, George H. Co.	59[illegible]
Reynolds, Silas H.	160[illegible]
Reynolds, Silas H.	16[illegible]
Reynolds, Annie	4[illegible]
Reynolds, Elizabeth	10[illegible]
Russell, F. H.	1,6[illegible]
Rixford, Emmett	[illegible]
Rinaldi, C. B.	
Reid, E. W.	
Robinson, Chas. W.	
Samly, J. A.	
Siefried, Flora L.	
Skinner, Max M. and Harriet T.	
Skinner, J. V.	
Skinner, Maggie J.	
Skinner, C. A.	
Skinner, C. A.	
Skinner, C. A.	
Stewart, J. J. and Catherine	
Southern Pacific Railroad Co	
Southern Pacific Railroad Co	
Stecker, August	
Silva, Manuel	
Turner, John R.	
Treglown, Wm. T. est	1,
Thompson, J. W. et al	
Tucker, Simeon	
Veeder, C. E.	
Vaughn, David	
Vaughn, Lydia	
Watterson, M. Q.	
Wrinkle, S. C. F.	
White, Benj. J.	
Williams, W. A.	
Wheeler, Fred. F.	
Walker, Ed.	
White, Est. C. R.	

Name of Seller.	Acreage.
Mechem, O. G. and W. A. Rhem	6.15
Markle, Richard	4.77
Markle, Richard	.02
Minter, Wm. T. (for power line)	00.
Mortimer, C. White et al	8.22
Manzana Colony et al	12.
Morrell, Peter	00.
Newhall Land and Farming Co	43.07
Newhall Land and Farming Co	90.00
Powell, J. F.	4.50
Powell, Florence et al	1.56
Phillips, L. Ernest (for telephone line)	00.
Raggio, Salome B. de, et al	1.90
Shideman, B. (inc.)	16.95
Southern Trust Co.	1.62
Summit Lime Co.	7.79
Summit Lime Co.	1.95
Snell, Huldah	3.03
Saugus Gold Mining Co.	11.15
Saugus Gold Mining Co.	5.85
Security Savings Bank	7.57
Toll, Jane L.	3.30
Watson, David J.	2.75
Walk, Albert B.	1.63
Total	83,250.38

LANDS AND RIGHTS OF WAY SECURED FROM THE UNITED STATES, UNDER THE ACT OF JUNE 30, 1906.

Aqueduct line in Los Angeles Land District.

Fairmont Reservoir site in Los Angeles Land District.

Dry Cañon Reservoir site in Los Angeles Land District.

King's Cañon pipe line in Los Angeles Land District.

Power and telephone lines in San Francisquito Cañon in Los Angeles Land District.

Hogback Creek pipe line, near Haiwee, in Independence Land District.

Cottonwood Creek power house site, in Independence Land District.

SPECIAL USE PERMITS, ISSUED BY THE FOREST SERVICE OF THE UNITED STATES.

Location.	Purpose.
Haiwee Creek	Ditch.
Haiwee Creek (amendment)	Ditch.
Hogback Creek	Ditch.
Cottonwood Creek	Pipe Line.
South Portal of Elizabeth Lake Tunnel	Construction Camp.

Name of Seller.	**Acreage.**
Sage Canyon	Pipe Line.
San Francisquito Canyon	Power and Telephone Lines.
Cottonwood Creek	Pipe Line.
King's Canyon	Pipe Line.
Cottonwood Creek	Telephone Lines.
Cottonwood Creek	Drift Fence.
Division Creek	Pipe Line and Power House.
San Francisquito Canyon	Construction Camp.

PROCEEDINGS IN THE DEPARTMENT AT WASHINGTON, IN WHICH APPEARANCE HAS BEEN MADE IN BEHALF OF THE CITY FOR THE PURPOSE OF A CONTEST, ADJUSTMENT OR OTHERWISE.

Contest with George Chaffey in re his application for reservoir sites on Cottonwood Creek.

Contest with George Chaffey in re his application for rights of way on Cottonwood Creek.

Contest with George Chaffey in re his application for rights of way on Oak Creek.

Contest with George Chaffey in re his application for rights of way on Shepherd's Creek.

Contest with George Chaffey in re his application for rights of way on Independence Creek.

Contest with George Chaffey in re his application for rights of way on George's Creek.

Contest with the Silver Lake Power & Irrigation Company in re its application for reservoir site in Long Valley, Mono County, Cal.

Contest with the Silver Lake Power & Irrigation Company in re its application for rights of way on Owens River.

Contest with the Round Valley Water Users' Association in re its application for rights of way on Rock Creek.

Contest with T. R. Smith in re his application for rights of way on Rock Creek.

Contest with the Owens River Water & Power Company in re its application for rights of way on Owens River.

Contest with the Mono Power Company in re its application for rights of way on Owens River.

Contest with Grant and Anton in re their application for rights of way on Cottonwood Creek.

Adjustment with A. W. H. Smith in re his application for rights of way on a stream designated in said application as Taboose Creek.

Adjustment with A. W. H. Smith in re his application for rights of way on a stream designated in said application as Birch Creek.

Contest with J. M. Taylor in re his application for rights of way on Owens River.

SUITS AFFECTING THE AQUEDUCT.

The City of Los Angeles vs. Daniel Curtis et al. Superior Court Los Angeles County. To condemn rights of way. Dismissed.

The City of Los Angeles vs. Daniel Curtis et al. Superior Court Los Angeles County. To condemn rights of way. Compromised with all parties but one, with whom compromise is being negotiated.

John F. Dixon vs. Fred Eaton et al. Superior Court Inyo County. To condemn rights of way. On demurrer.

Inyo Consolidated Water Company vs. Stoddard Jess et al. Superior Court Inyo County. To quiet title to waters of Cottonwood Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Oak Creek. On demurrer to amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Lone Pine Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Independence Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Shepherd's Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of George's Creek. On demurrer to second amended complaint.

City of Los Angeles vs. Jameson Lime Company et al. Superior Court Kern County. To condemn right of way. On demurrer.

City of Los Angeles vs. Bridget McGann. Superior Court Inyo County. To condemn rights of way. Compromised as to all defendants but one, with whom compromise is being negotiated.

Owens River Land & Cattle Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to lands. On demurrer.

Silver Lake Power & Irrigation Company vs. City of Los Angeles. Superior Court Mono County. To quiet title to waters of Owens River and other streams. Demurrer of City sustained. Plaintiff has time to amend.

Silver Lake Power & Irrigation Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Owens River. On demurrer to amended complaint.

City of Los Angeles vs. Yandell, Administrator of White Estate. Superior Court Inyo County. To quiet title to lands. Judgment against City.

City of Los Angeles vs. Yandell, Administrator of Stevens Estate. Superior Court Inyo County. To quiet title to lands. Judgment against City.

A. St. Clair Perry vs. City of Los Angeles et al. Superior Court Los Angeles County. To enjoin the construction of the outfall sewer, and other public works, in any other manner than by contract based on competition. Demurrer to complaint sustained and suit dismissed.

E. R. Fox vs. A. A. Hubbard et al. Superior Court Los Angeles County. To enjoin construction of the Jawbone Division of the Aqueduct in any other manner than by contract based on competition. Demurrer to complaint sustained and suit dismissed.

24 1910

CITY OF LOS ANGELES
Department of Public Works

FOURTH ANNUAL REPORT
of the Bureau of the
LOS ANGELES AQUEDUCT
THE BOARD OF PUBLIC WORKS

BOARD OF PUBLIC WORKS:

ALBERT A. HUBBARD, President
LIEUT.-GEN'L ADNA R. CHAFFEE
W. M. HUMPHREYS

LOS ANGELES, CALIFORNIA
1909

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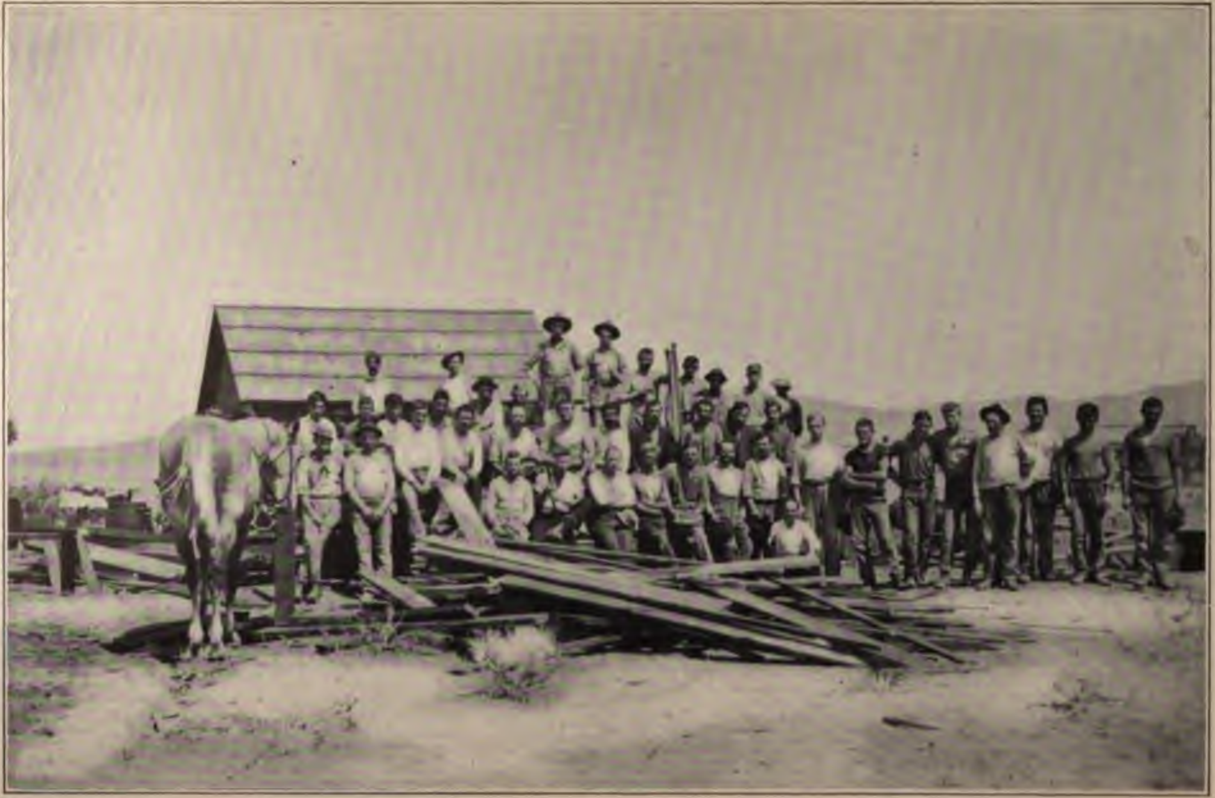


PRIZE TUNNEL CREW—LOS ANGELES AQUEDUCT

This crew made a footage of 1061 feet at the north end of Tunnel 17 M, during the month of August, 1909, which is the world's record in tunnel driving.

BOARD OF PUBLIC WORKS
OF THE CITY OF LOS ANGELES

BUREAU OF THE LOS ANGELES AQUEDUCT

WM. MULHOLLAND, *Chief Engineer*
J. B. LIPPINCOTT, *Asst. Chief Engineer*

Los Angeles, Cal., July 1, 1909.

To the Honorable Board of Public Works,
City of Los Angeles.

Gentlemen: The amendments to the Charter changing the ending of the fiscal year curtails the period covered by this report to seven months. Necessarily this prevented the completion of the construction program outlined in the last report, but an examination of the progress tables will show that we were in a fair way to exceed the advance therein anticipated.

The organization has now settled down to a steady pace free from the confusion necessarily incident to the launching of such an unwieldly project, and the men in charge of each division, and their subordinates, are becoming every day more proficient in the management of the work assigned them.

The people of this city can hardly appreciate how fortunate they have been in procuring the services of so many competent, earnest and enthusiastic engineers and superintendents as are employed on this work. Everywhere exists a spirit of rivalry between the camps, friendly it is true, not alone as to the speed of executing the work, but also as to its quality and cost. This is not wholly accounted for by the reward obtained by the bonus system adopted by your Honorable Body, because the engineers and head men generally do not participate in this advantage, but it is altogether to be attributed to innate loyalty and devotion to duty.

It will be seen that the program laid out for next year, if accomplished, will carry the work beyond the half-way mark in point of mileage, and as the more difficult portions of the work were first undertaken, such as tunnels and rough mountain work, it can readily be seen that in point of cost, at least 60 per cent. of the work will be completed by that time.

The Aqueduct has been abundantly supplied with labor until about three weeks ago, when a scarcity began to be felt and which at the present time leaves us considerably short handed in some of the out-door camps. This may be attributed to two causes: first, the warm weather, which makes the conditions of the desert somewhat arduous in the summer time; and second, the demand at this time for harvest hands. The distraction of the approaching festivities, due to the nearness of the Fourth of July and the Elks' meeting in Los Angeles, may also account for some of the shortage. It is to be hoped, however, that this condition is but a temporary one.

There is no summary in this report of the water flow of the Owens Valley, due to the fact that the observations are not yet compiled and cannot be intelligently discussed until the season is farther advanced.

The review of the hydrological conditions of the next report, however, will cover a period of a year and a half, and should be interesting, as it will contain data relating to an extreme dry year, in addition to one with a snowfall much larger than normal.

Thanking the Board for its many courtesies, and its constantly expressed appreciation of the efforts of myself and colleagues, this report is respectfully submitted.

WM. MULHOLLAND,
Chief Engineer.

REPORT OF THE ENGINEERING DEPARTMENT FISCAL YEAR ENDING JUNE 30, 1909

Owens Valley Division (No. 2)

There are two dredges now at work on this division, one working northerly from Station 170 and the other working northerly from Station 739, a little north of the Citrus Road. Both these machines are now in first-class order and working two ten-hour shifts and are making a progress of about 40 feet each per shift, or 160 feet per day. The dredges are operated by power delivered from Division Creek Power Plant No. 2, completed since the last report. The amount of canal already completed in this division is about 11,500 feet. Dredge No. 1 at first started south, and was operated in that direction until it struck a heavy lime or travertine deposit opposite Saw Mill Creek. This deposit extends for a distance of about one mile, and requires heavy blasting, and is otherwise incapable of being excavated by suction dredges. A dipper dredge has been ordered to complete this work. This dredge is so designed that the machinery portion of it will be adapted to excavation on the Alabama Hill Section by simply mounting it on frame work similar to that designed for the other excavators to be used on this section. Division Creek Power Plant No. 2 will operate all three of these machines in Division No. 2, as its capacity has been fully tested, and its operation is smooth and efficient. This plant has been wired also to connect with the Cottonwood Plant and synchronizes therewith, so that whatever surplus power may be generated which is not required on Division No. 2 may be transferred down the line to be used on tunnel and other construction operations on the Grapevine Division, and whatever surplus still remains will be transferred to the Cement Plant at Monolith. At present the transportation facilities into Owens Valley are not yet perfected because the Nevada & California Railway from Mojave is still 65 miles south of Independence. It is now planned that this railroad will run west of Owens Lake along the line of the canal as far as Lone Pine. This will be a great accommodation to our construction work. It is not economic to do any extensive concrete work in this valley until after the railroad is built.

The question of water supply for construction purposes in this division is easily solved. Deep wells have been put down along the line of the canal where dredging is to be done, and an abundant flow of artesian water sufficient for the hydraulic work has been developed. Labor conditions in this valley are more difficult than in any other division, as it is close to the Nevada mines, where high prices are paid for labor. This district also has in the past been accustomed to a generally higher rate of wage than exists in Southern California. No work is being done under contract. This division is in charge of H. A. Van Norman, electrical constructor, and V. R. Franklin is chief clerk of the division.

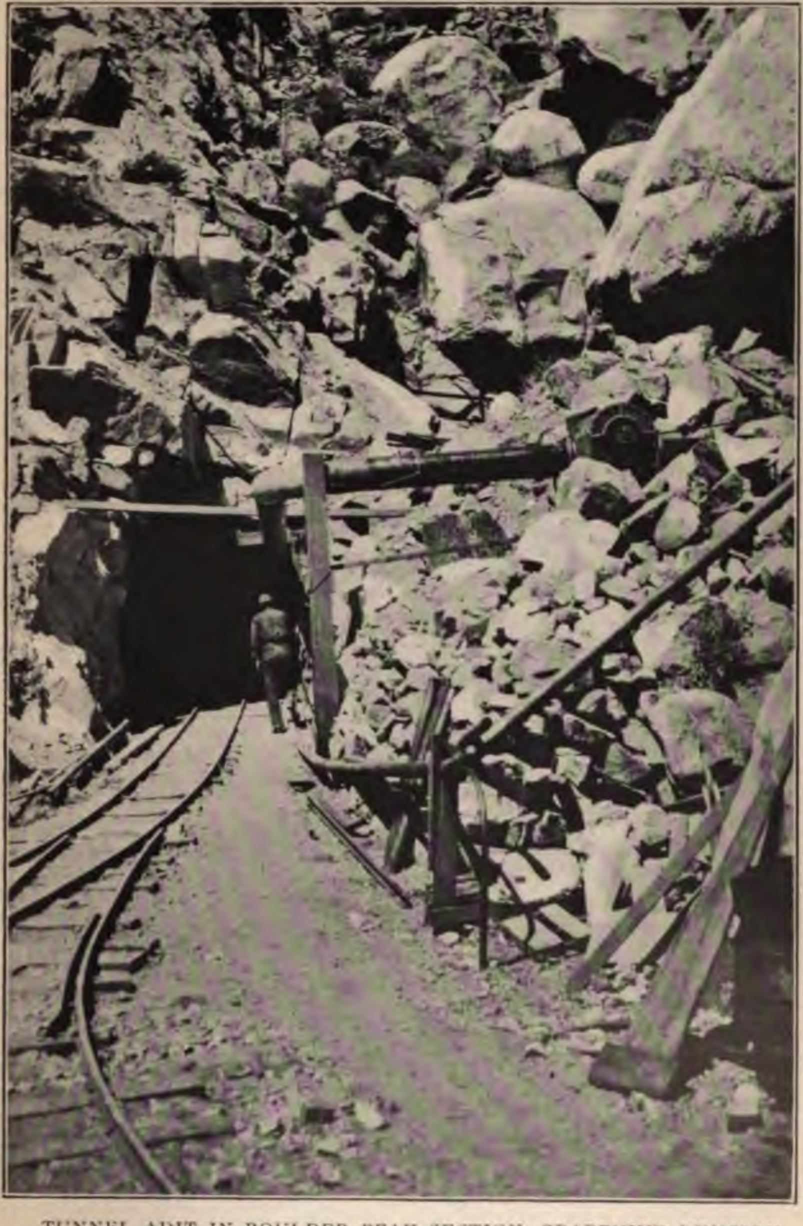
The Cottonwood Power Plant has been in continuous operation since the last report, and is giving excellent satisfaction, both in regard to operation and output; and inasmuch as the penstock and canal have been built with a capacity to operate two generators of the size of the one now there in use, it is deemed advisable to add a second unit. Most of the machinery for this is now on the ground, and will be installed at an early date. Snowfall on the water shed of the Cottonwood Plant was sufficient last winter to insure continuous operations of both generators for the coming year, and it would seem, from close observation of the yield of this water shed, that both units may be operated during quite a large proportion of the time of even dry years, so that the investment in the second unit may be regarded as a safe one commercially.

Olancha Division (No. 3)

As recommended in the last report, an excavator has been ordered for this work. This machine is of special design, as the cross section of the canal through this division is large, requiring a range of boom greatly in excess of that of the ordinary steam shovel such as is used on 400 sec. ft. divisions of the work. The material to be handled also is of special character, requiring machinery to be of great weight and endurance. This material consists in places largely of very heavy boulder deposits, some of the fragments being large enough to require blasting. It is expected that work will be commenced in this division by August 15, by which time the railway will probably be completed to Olancha, which will allow of cement being delivered to follow up the excavation.

HAIWEE RESERVOIR

It was expected that work would be begun this spring on the Haiwee Reservoir, but as this work requires the use of a



TUNNEL ADIT IN BOULDER PEAK SECTION, GRAPEVINE DIVISION

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steam shovel, it has been thought best to defer it until one of the shovels in the Mojave Division can be released, in order to save heavy equipment expenditures. Another reason is that since all our work has to be rated by the capacity of the Cement Mill, it was not considered expedient or economical to buy power shovels beyond the actual number necessary to keep pace with the mill production. It is expected that the shovel will be released by January 1, 1910, when the other equipment necessary for the construction of the dam will be in place and ready for operation. As stated in the last report, the work on this dam will require about one year for its completion.

Rose Valley Division (No. 4)

For the reasons given in the last report, it is not expected that any work will be done on this division during the coming fiscal year, unless progress is rapid enough in the Freeman Division to release some of the power shovels to be used therein.

Little Lake Division (No. 5)

That portion of the located line known as the Grapevine Division has been divided into three divisions for construction purposes: the Little Lake Division extending from Rose Valley to No Name Siphon, the Boulder Peak Division extending from No Name Siphon through a very precipitous and mountainous country requiring tunneling, to a point near Sand Canyon, and the Grapevine Division proper extending from Sand Canyon to Indian Wells Canyon. The Little Lake Division consists largely of steep side hill work requiring extensive tunneling. This division as now planned will contain 30,300 feet of tunnels, 18,800 feet of side hill conduit and 5,820 feet of siphon. A central compressor plant has been established at Soda Springs Canyon to furnish the necessary motive power for driving some 15,000 feet of tunnels. Another plant is being established in the Dead Horse Canyon to furnish power for driving tunnels in the extreme northern end of the division. This division is subject to frequent cloud-bursts and, therefore, the line has been located largely in tunnels set well back in the mountain, with adit openings so that the line is entirely free from the danger of erosion. The formation permits of economical tunnel driving.

A system of wagon roads has been built so as to command the work of the entire division. Up to June 30, twelve tunnel headings have been opened and 3,435 feet of tunnel driven. The equipment has been purchased and the work so organized that after building the northern group of tunnels in this division, the men and equipment can be transferred to the south group so as to complete them within the time required. There are 150 men employed on this division.

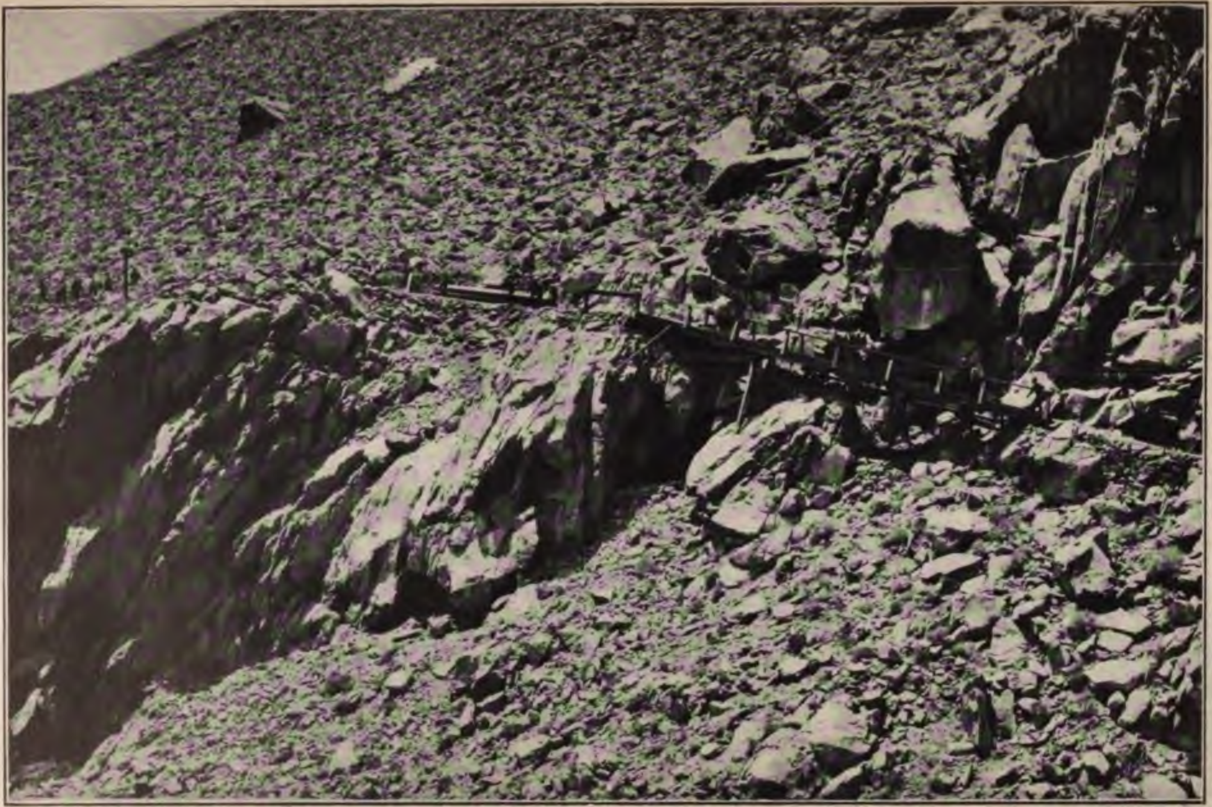
The railroad has been completed beyond this point, and Siding 20 (Narka Station) has been established at the foot of the principal road system. The water supply is obtained from the Little Lake Canyon and brought to the camps through pipe lines for a distance of five miles. It is good in quality and under sufficient pressure to command all portions of the work in the northern half of the division. In the southern end water is obtained under pressure from Five Mile Canyon. Labor conditions are satisfactory, and all the work is being done by the city by day labor. This division is in charge of C. H. Richards, assistant engineer, and E. W. Breitkreutz is chief clerk.

Boulder Division (No. 5-A)

This division extends from the south end of No Name Canyon to the center of Tunnel 16, near the north side of Sand Canyon. It contains 10,050 feet of tunnels and 900 feet of side hill conduit. Work started on these tunnels March 10, 1909. This portion of the line is as difficult as any heretofore encountered, the rock being very hard granite, and the mountain side so precipitous that it is considered necessary to put the conduit under ground so as to avoid rolling rocks and cloud-bursts, which might interfere with the maintenance of the Aqueduct.

Brown Station, on the Nevada & California Railway, is the base of supplies for both the Boulder and Grapevine Divisions. A road system has been constructed commanding the southern portion of this division, and hoists will be installed to lift men and material to work in the northern end. Road building here is quite expensive, as the rock is hard and practically at the surface at all points. The water supply is furnished from Nine Mile Canyon and is adequate in pressure and in quantity. Labor conditions are satisfactory, as the greater portion of the organization was brought by the engineer in charge from the Jawbone Division after the completion of a set of tunnels in the Sugar Loaf District. Five tunnel headings are being driven. The equipment was transferred from completed portions of the Jawbone Division. All work is being done by day labor by the city. There are 120 men on this work.

L. S. Preston is in charge of this division, and A. C. LaRue is chief clerk.



TRAIL TO TUNNEL 12 IN BOULDER PEAK SECTION, GRAPEVINE DIVISION

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Grapevine Division (No. 5-A)

Headquarters for this division are situated in Sand Canyon, where a hospital and machine shop have been installed. A tunnel driving plant has been built in Sand Canyon which will furnish compressed air to the group of tunnels in this district. The rock in this section is very hard and machine drills will be required in all tunnel driving. Five tunnel headings are being driven in this section. The necessary equipment was transferred from the completed portions of the Jawbone Division. When this group of tunnels has been completed, the equipment will be removed to Grapevine Canyon, where the remainder of the tunnels in the division are located, and it is estimated that all work can be completed with the equipment on hand, thus avoiding additional purchases.

A Model 40 Marion steam shovel has been purchased for side hill conduit excavation work and has been installed on the side of the mountain immediately north of the Grapevine Canyon. A concrete lining crew has been organized, and will follow the shovel work. In addition to a road system which has been built for wagon haul, hoists will be installed in Grapevine and Sand Canyons to lift the men and material to the work on the mountain side. The located line is about 400 feet above the base of the mountain. The supply depot of this section is at Brown Station, and traction engines have been assigned to do the hauling to the foot of the hoists. The water supply has been provided for, a pumping station having been installed in the Grapevine Canyon, which will lift water up to the line. Another pumping station has been installed in Sand Canyon to deliver water on the line, and a pipe system from Nine Mile Canyon has been connected with the same system of mains, so that water can be sent through the line in either direction as required. Labor conditions are satisfactory, and all work is being done by the city by day labor. This section is in charge of H. A. Petterson, assistant engineer. He is assisted by Ward Blackburn, tunnel superintendent, and F. F. Prendergast, construction superintendent. Carl M. Cooper is chief clerk.

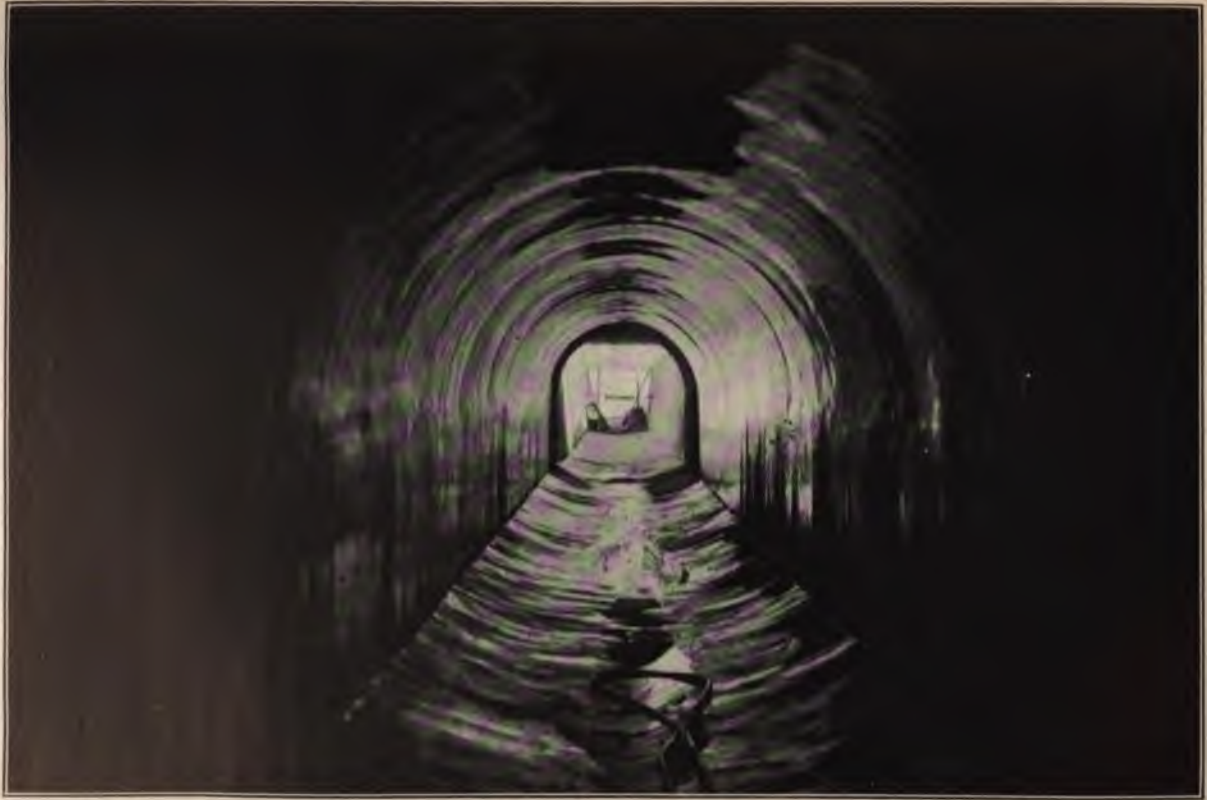
Freeman Division (No. 6)

The work on this division is in charge of Louis F. Mesmer, construction superintendent. Mr. Mesmer was in charge of Shovel Camp No. 2 on the Mojave Division, where he made a satisfactory record, and built up an efficient organization. As the work in the Freeman Division is similar, Mr. Mesmer has been transferred to it. The division consists of 103,600 feet of conduit. One Model 40 Marion steam shovel and two electric power shovels have been purchased for this work, and a third electric power shovel will be transferred to the Freeman Division from the Jawbone Division when its work is completed there, about July 1. These four shovels should do about two miles of excavation a month, and should finish the division within a year, after which period they will be available for transfer to Rose Valley or other sections of the Aqueduct. The work is uniformly open desert construction. Four hundred men will be employed on the division. The base of supplies is the warehouse at Dove Springs Camp, at the upper end of the Red Rock Railroad. The city owns and operates this spur, which is 8½ miles in length from the warehouse at Dove Springs. The hauling will be done principally by traction engines.

Water is supplied under pressure on this portion of the line from Sage Canyon southerly. Another pipe line is being laid from Dixie Wash northerly, so that the entire division will have water under pressure. Labor conditions so far have been satisfactory. All work is being done by day labor by the city.

Jawbone Division (No. 7)

This division consists of 59,448 feet of tunnel, 44,717 feet of conduit, 13,448 feet of siphon and 250 feet of flume. There were originally 43,560 feet of tunnel in this division, on which work was begun in September, 1908. At the present time there are but three of the original tunnels left to be completed, but by some minor alterations and improvements on the line in this division, suggested by the actual work, the tunnel mileage has been extended with advantage both in economy and security. The greatest change was in boring through the Red Rock Summit, instead of going around through a very rough piece of country. This tunnel not only shortens the mileage on the Jawbone Division, but cuts 20,000 feet off the Freeman Division, and the rate of progress now being made, together with the cost of same, fully justifies the change. Another important change in the division, suggested by Mr. Hansen, has resulted in the cutting out of a siphon and the substitution therefor of a series of tunnels around the gulch, across which this siphon was to be built. This substituted work is now nearly completed, and its cost amply justifies the change. Concrete lining is now progressing in this division at the rate of 45 feet per day in open work and 93 feet per day in tunnels, and it is expected that,



LINED TUNNEL IN JAWBONE DIVISION

with the exception of the siphons, all work in this division will be completed by January 1, 1911.

The division headquarters and base of supplies are at Cinco Station, on the Nevada & California Railway. Other warehouse supply stations are at Dove Springs on Section 1 and Siding 4 (called Pine) for Section 3. The machine shop and hospital are located at Cinco. Air compressing stations for tunnel driving are installed at Sugar Loaf, Water Canyon, Sand Canyon, Pine Tree Canyon and Midway Canyon. These stations consist of air compressors electrically driven, motor generator sets, electric locomotives, blowers, etc. Hoisting stations have been erected at Cliff Ridge and at Midway. All motive power is furnished by the city's hydro-electric plants.

The following amount of work has been accomplished up to June 30:

	Excavation	Lining
Tunnels	45,740 feet	11,739 feet
Conduit	25,090 feet	7,445 feet

About 1,000 men are employed on this division. Hauling is done principally by traction engines. These engines are transporting freight at a cost of about 50 per cent. of the lowest price bid for this hauling by teams in response to advertisements. The entire division has a water supply under pressure, that for the northern half coming from Sage Canyon and for the southern half from the Tehachapi Canyon near the Cement Plant. Labor conditions are satisfactory, and all work is being done by the city by day labor.

This division is in charge of A. C. Hansen, assistant engineer. He is assisted by tunnel superintendents Ripley and Flanigan, and construction superintendents Heckler, Grohs and Brittain. B. H. Craft is chief clerk.

Mojave Division (No. 8)

The work in this division consists uniformly of open desert construction with steam shovels, the line as located crossing the Southern Pacific Railway three miles north of Mojave station. The two shovels mentioned in the last report have been diligently at work on this division and have exceeded the anticipated rate of progress. Excavation is now being carried on at the rate of 3,000 feet per month each, and the concrete lining is being completed behind them. There has been some delay in procuring reinforcing material for the conduit cover, so that this portion of the work is somewhat in arrears. 27,154 feet of lined conduit have been completed on this division. The base of supplies of this division is Mojave, on the Southern Pacific Railway, and the hauling is being done by Contractor A. C. St. John, at the rate of 25 cents per ton mile. Roads have been built for the entire length of the division, and water under pressure is available at all points on the work, the supply being obtained both from the Tehachapi wells and from Oak Creek. Labor conditions have been satisfactory. With the exception of the hauling contract, all work is being done by the city by day labor.

This division is in charge of J. H. Robinson, assistant engineer. He is assisted by construction superintendents Carruthers and Rolfe. Philip Wintz is in charge of the Austin excavator, and L. T. Goble is chief clerk of the division.

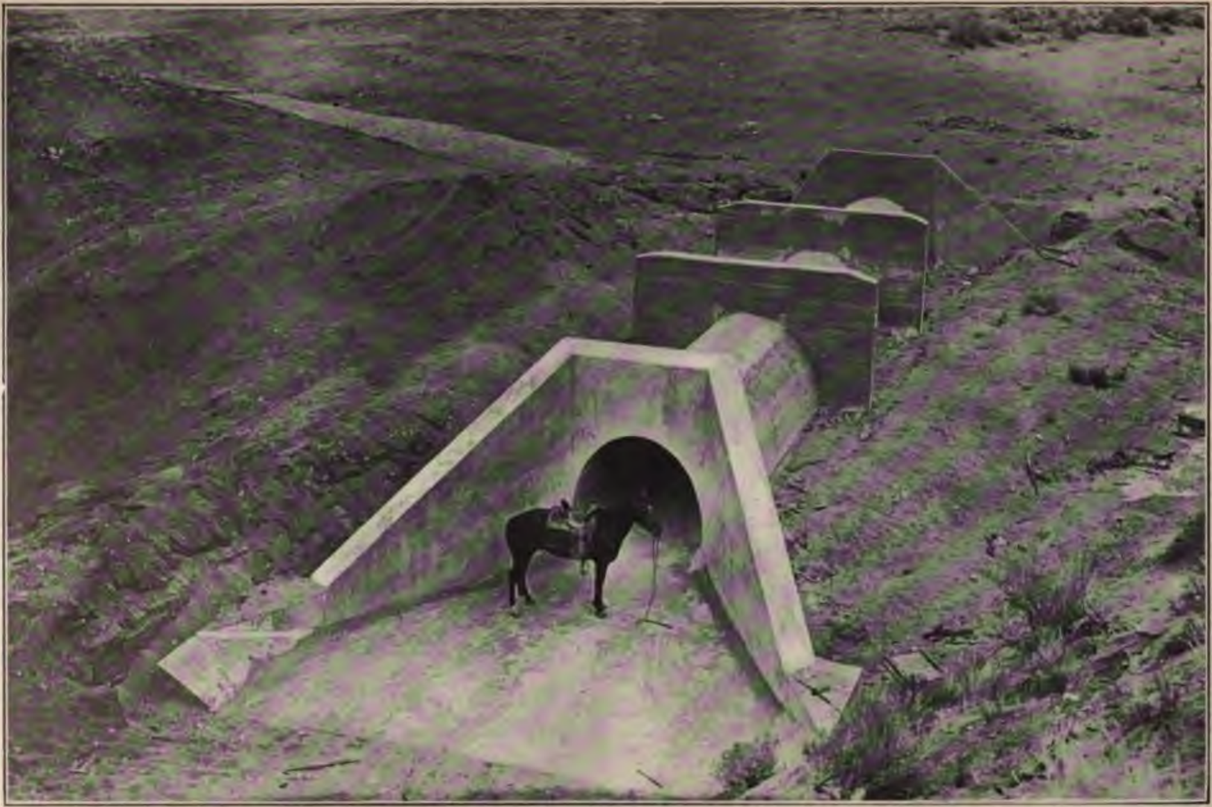
Antelope Division (No. 9)

Headquarters for this division are on the north side of the Antelope Valley in the locality known as the Sand Hills. The base of supplies for work on the north side is Mojave, and for the work on the south side, Lancaster. Work in this division consists of 14,878 feet of tunnel, 101,112 feet of conduit, 26,909 feet of siphon and 270 feet of flume. The greater portion of the tunnels is on the north side of the valley in the Sand Hills. Work was started in this part of the division in February, 1909. The tunnels are being driven by hand, and the conduit is to be excavated by a gasoline power shovel. At the present time 4,590 feet of tunnels have been driven and 400 feet of conduit have been constructed.

On the south side of the Antelope Valley work was started by the city by day labor in September, 1908. On the 12th of December that portion of the located line included between the south end of the Antelope Valley Siphon and the Fairmont Reservoir, was let to Contractor P. A. Howard at the following rates:

Item 1.	$30.00 per lineal foot for completed and lined tunnel.
Item 2.	$12.00 per lineal foot for lining tunnel excavated before the execution of this contract.
Item 3.	$6.20 per lineal foot for canal lining with cover and backfill.
Item 4.	40 cents per cubic yard for excavation.
Item 5.	$8.00 per cubic yard for plain concrete in the culverts.
Item 6.	$8.00 per cubic yard for rubble concrete.

Contractor Howard began work early in January, and up to the present time 820 feet of tunnels have been driven and 6,322 feet of conduit excavated. The conduit construction is



LARGE CONCRETE CULVERT ON HOWARD CONTRACT, ANTELOPE DIVISION

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largely in the prevailing desert soil, and the tunnels are mostly in a soft, decomposed granite. There are 130 men on the city pay rolls in this division and 100 men employed by the contractor.

Hauling on the north side of the division is done both by traction engines and wagons. On the south side of the valley the contractor is hauling with wagons from Lancaster, at which point the city makes delivery of cement, steel and lumber for the contractor's use. Water is supplied for the northern side of the division from a pipe line extending from the Antelope Valley Cottonwood Wash to the north end of the Neenach Siphon, a distance of 11 miles. This pipe line is an extension of the Mojave Division branch of the Tehachapi-Jawbone pipe line, which is 30 miles long. This pipe line system is supplemented by water obtained from the Oak Creek pipe line, which is about 6 miles west of Mojave, and by water from a spring in the Antelope Valley Cottonwood Wash. This pipe line system is continuous from the north end of the Neenach Siphon to Cinco, the headquarters of the Jawbone Division, about 54 miles. On the south side of the valley, water is supplied from Kings Canyon, which pipe line extends from Neenach to the North Portal of the Elizabeth Tunnel. Labor conditions in this division have been satisfactory.

The division is in charge of Burt Harmon, assistant engineer, assisted by tunnel superintendents Jenks and Wright, and construction superintendent Clotts, who is detailed as the representative of the city to Contractor Howard's work. A. E. Ohse is chief clerk.

Elizabeth Division (No. 10)

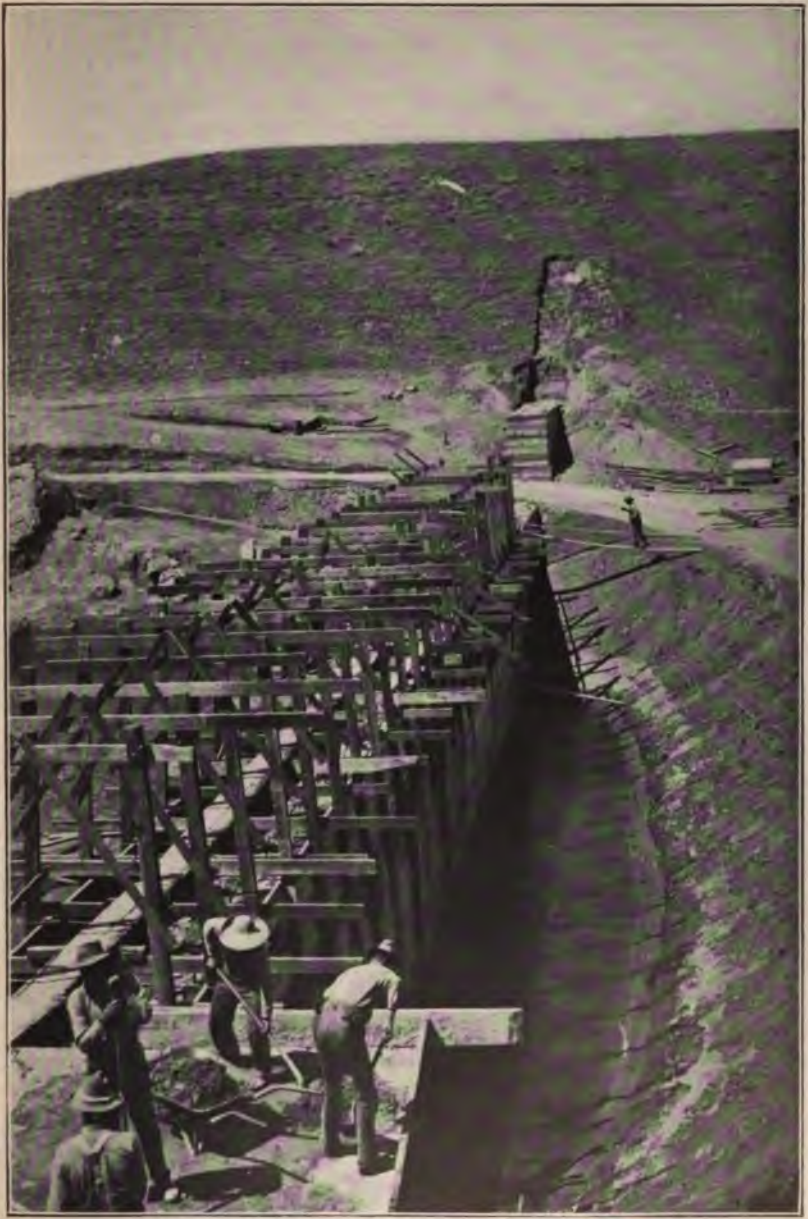
Progress on this important feature of the Aqueduct has been satisfactory since the date of the last report. 5,174 feet have been driven from that date up to the first of June of the present year, making a distance of 9,746 feet in all. It is reasonable to assume that a rate of progress of 20 feet per day can be maintained on this tunnel until completed, which would fix the date for the finishing of excavation at approximately Oct. 1, 1911, following which it will take about one year to complete the concrete lining. The north end of this tunnel is in charge of John Gray, tunnel superintendent. A machine shop, hospital and complete tunnel plant in duplicate have been installed. A shaft was sunk at a point 3,000 feet south of the portal and a tunnel driven both north and south from the bottom. Work from the portal and the shaft met in a satisfactory manner on April 10, and the tunnel is now being driven entirely through the portal heading. The character of the ground has changed rapidly from one formation to another, consisting of disintegrated granite, tough blue clay, hard granite, slate and saturated sand. This sand was encountered at Station 11+35, and because of the resulting delay to the work, the shaft referred to above was put down. This sand stratum was allowed to drain out, and a small heading then driven through it. The deposit was only 25 feet through, but it gave a great deal of trouble and caused considerable delay. The heading now is in hard blocky granite, and good progress is being made. Up to June 30th, 4,878 feet of tunnel excavation have been completed. Electric power is supplied from the Edison system from Castaic, from which point it is conveyed over the city's line through the Saugus Division to both ends of the Elizabeth Tunnel.

As it is intended that the lining of this tunnel shall commence at an early date, a complete plant for such work is now being erected.

The core wall of the dam of the Fairmont Reservoir is about complete, but it has been decided to await the coming of the Owens River water before attempting the earth work, for the reason that the building of this dam is not provided for in the bond issue, and for the further reason that the volume of such earth work is so great that the saving that may be effected by filling it in by the hydraulic process is sufficient inducement to defer the work until water can be had to adopt that method. The delay in the construction of this dam will not interfere with the conveyance of the water through the Aqueduct, as the function of this reservoir is largely one of regulation for power purposes. About 200 men are employed at this point.

The base of supplies is at Lancaster, and hauling is done by contract with J. A. Hill. Labor conditions are satisfactory, and all work except hauling is being done by the city by day labor.

The South Portal of the Elizabeth Tunnel is in charge of W. C. Aston, tunnel superintendent. A machine shop, complete tunnel driving plant in duplicate, and hospital have been installed. The character of the rock at this end has been very uniform and favorable. It is gneissoid granite, which drills well, but is tough and gnarled, requiring a large amount of powder per foot to break it. The amount of work accomplished during the past seven months at this end of the tunnel has been quite remarkable. It has been as follows:



CORE WALL OF FAIRMONT DAM

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December	206 feet
January	383 feet
February	319 feet
March	474 feet
April	453 feet
May	351 feet
June	251 feet

The distance of 474 feet run in March, 1909, is the American record for driving hard rock tunnels.

About 150 men are employed at the South Portal. The base of supplies is Lancaster. The hauling is done by Contractor J. A. Hill, but all other work is being done by the city by day labor. The water supply is from local wells and pipe systems. Labor conditions have been quite satisfactory, with the exception of a short suspension resulting from a reduction in the bonus schedule on June 1.

Saugus Division (No. 11)

Work on this division consists of 54,040 feet of tunnel, 11,045 feet of conduit, 21,158 feet of siphon and 1,875 feet of flume. Work on the division was begun in October, 1908, and has been actively prosecuted. All tunnels on this division are being driven by hand, although tunnel plants were installed for both ends of the long Newhall tunnel, and a plant was purchased for the slate tunnel, (No. 73, in Section 1) in anticipation of encountering harder material. This equipment was found unnecessary, as the rock is soft enough to bore with hand augers, with the exception of Tunnel 73, where hand hammer drilling is required. The equipment was therefore transferred to work on the Little Lake and Grapevine Divisions, where machine drilling is necessary. In Sections 2 and 3 the tunnels all require timbering, but in Section 1 they are being driven largely without timbering. The following work has been accomplished up to the present time:

	Excavation	Lining
Tunnel	21,102 feet	3,019 feet
Conduit	7,318 feet	222 feet

About 900 men are employed on this division. Headquarters are at Saugus. The work south of the Newhall tunnel, however, has for its base Tunnel Station on the Southern Pacific Railroad. Hauling for the division is being done under contract by J. A. Hill. The construction water supply in this division is quite a difficult problem. The water is pumped from wells to the grade, the wells being situated in the various canyons. Electrical energy is obtained from the Edison Electric Company, a transmission line having been constructed from the sub-station at Castaic. Labor conditions are quite satisfactory, all work being done by the city by day labor, with the exception of the hauling contract referred to above.

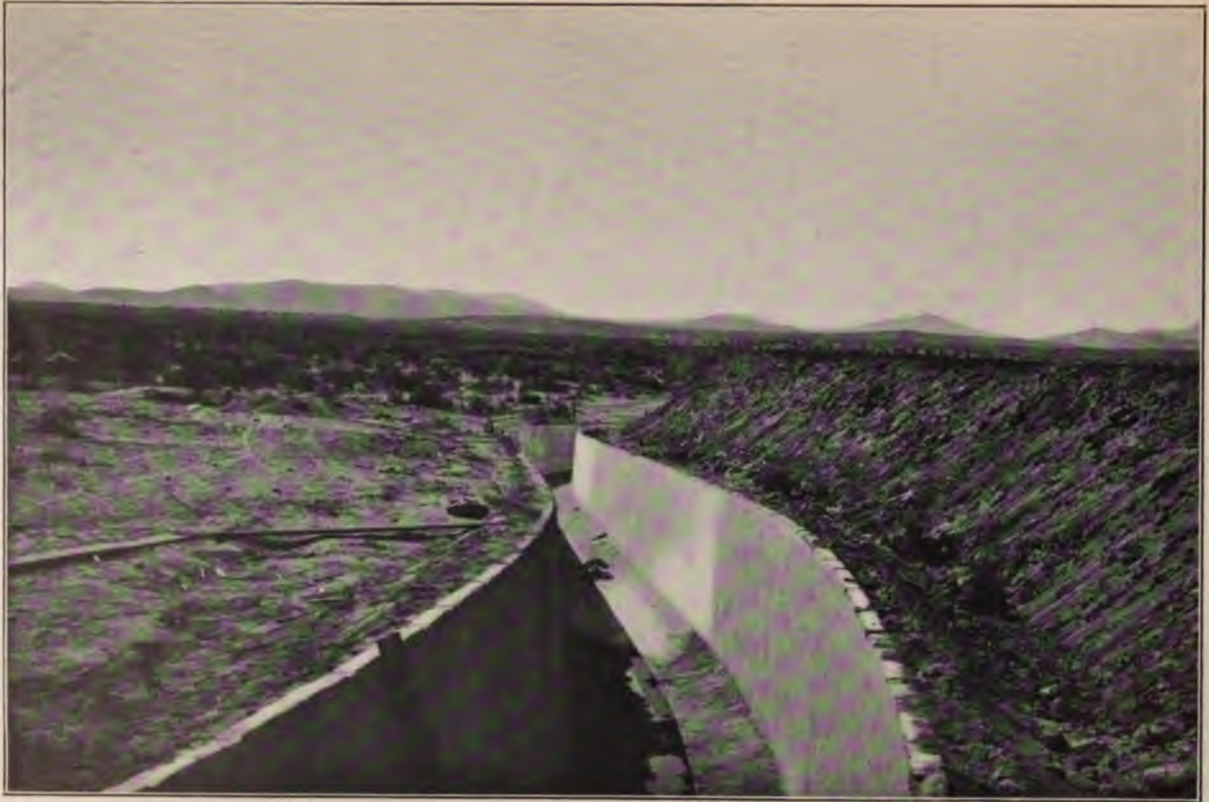
D. L. Reaburn, assistant engineer, is in charge of this division, and is assisted by tunnel superintendents F. J. Mills and J. W. Henderson. A. P. Cox, construction superintendent, is in charge of the concrete work, and E. F. King is chief clerk.

Cement Plant Division (No. 13)

The cement plant built by the city at the station now known as Monolith, on the Southern Pacific Railroad, was put in operation April 1, 1909. No expense has been spared to make this plant completely modern in all its details, as on its successful operation depends, in a large degree, the speedy completion of the Aqueduct. These works are designed for a normal capacity of 1,000 barrels per day, an output which has not yet been attained, due for the most part to the usual minor breakdowns and adjustments inseparable from the starting of such a huge train of machinery. Some of the trouble is, of course, due to the inexperience of the men, but it is hoped that within a month or so, the mill will reach its maximum output. The cement has so far been of a superior quality, excepting a few small batches, which may be regarded as experimental blends on the part of the chemist. The materials used, however, are so even in composition that once the final standard of mix and treatment is established, nothing need be feared as to the quality of the product. The output during the latter part of June has been over 900 barrels per day.

Location Revision

The results of experience in, and the cost of all classes of construction work on the Aqueduct, except siphons, are now available. In general, the tunnel work has proved materially cheaper than the estimates of the engineering department, while short and disconnected pieces of side hill team or hand work have proved more expensive. A review of the line where construction has not yet progressed extensively has been made, and the location readjusted to meet the most economic and stable conditions. E. A. Bayley, assistant engineer, has charge of this general location review. The greater portion of the line is entirely satisfactory, but in some localities improvements have been made, either for safety or economy. F. J. Bates, instrumentman, has been made inspector of surveys, with instructions



CONDUIT IN RED ROCK COUNTRY, FREEMAN DIVISION

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to visit all construction work on the Aqueduct, and check the alignment at the headings of the tunnels and conduits. Forty-nine tunnels have now been completed, and in every instance satisfactory connections have been made.

Headquarters Organization

The Chief Engineer has general direction of all office and field work in the Engineering Department. The Assistant Chief Engineer reports to and represents the Chief Engineer.

Office Organization

The drafting room and cost keeping department in Los Angeles are under the direction of E. W. Bannister, assistant engineer, with the title of office engineer; including all computing, drafting, designing and compiling of records. He prepares all work orders specifically authorizing construction in the field, estimates the cost thereof and submits them to the Chief Engineer for his approval. The office engineer has authority to approve all requisitions. He reports to the Chief Engineer.

All cost reports from the field are compiled and arranged by O. E. Clemens, who is in direct charge of this work, reporting to the office engineer. Each month a report is made showing the amount of work performed and the current cost of each piece of work under construction. The costs for the previous month are compared with previous average costs and also with the engineering estimates. In case of unusual economy or excessive expense, correspondence with the field officer follows, either in commendation or criticism. This work has been made of unusual value and effectiveness, and each month reports are issued for the entire work to all division officers, in order that they may be given proper credit for their work and may study the relative cost of similar work on other divisions.

S. B. Norton is chief clerk of the Engineering Department. The duty of the chief clerk is to open and assign all mail addressed to the Chief Engineer, and either distribute it to the various offices for attention, or personally answer it. He also has charge of the letter and report files in the Engineering Department and attends to all routine office business. The chief clerk handles requests from the field for laborers and for other minor positions, and attends to the Civil Service business through the Board of Public Works. He has the general direction of construction clerks in the field performing duties relative to the assembling and reporting of costs or other engineering data.

He has charge of all inventories of property and the records of their transfers, and also keeps a personal record of all employes. The chief clerk reports to the Chief Engineer.

ESTIMATE OF CONSTRUCTION TO BE ACCOMPLISHED on Los Angeles Aqueduct during fiscal year ending June 30, 1910

No.	Divisions	Tunnel Excav. Lin. Ft.	Tunnel Lined Lin. Ft.	Conduit Excav. Lin. Ft.	Conduit Lined Lin. Ft.	Flume Lin. Ft.
2	Owens Valley			47,000		
3	Olancha			16,200	16,200	
5	Little Lake	18,000				
5-A	Boulder Peak	4,940				
5-A	Grapevine	7,260		12,000	12,000	
6	Freeman			109,200	109,200	
7	Jawbone	13,325	49,553	34,019	34,019	250
8	Mojave			62,400	62,400	
9	Antelope (N)	9,333	9,600			
9	Antelope (S)	368	1,668	30,000	30,000	
10	Elizabeth (N)	4,200	7,200			
10	Elizabeth (S)	4,200	7,200			
11	Saugus	32,040	57,600	4,546	11,046	
	Totals	93,666	132,821	315,365	274,865	250

ESTIMATE OF MONEY REQUIRED FOR CONSTRUCTION OPERATIONS during fiscal year ending June 30, 1910

No.	Divisions	Tunnel Excav.	Tunnel Lined	Conduit Excav.	Conduit Lined	Flume	Misc.
2	Owens Valley			$94,000			
3	Olancha			34,830	$129,600		
5	Little Lake	$324,000					
5-A	Boulder Peak	98,800					
5-A	Grapevine	145,200		12,000	69,600		
6	Freeman			54,600	709,800		
7	Jawbone	159,900	$396,424	68,038	238,133	$7,500	
8	Mojave			31,200	405,600		
9	Antelope (N)	93,330	76,800				
9	Antelope (S)	6,624	20,016	21,000	186,000		
10	Elizabeth (N)	210,000	57,600				
10	Elizabeth (S)	210,000	57,600				
11	Saugus	480,600	403,200	9,092	60,753		
	Administrat'n & Engineering						$250,000
	Owens Valley Ranches						10,000
	Totals	$1,728,454	$1,011,640	$324,760	$1,799,486	$7,500	$260,000

TOTALS

Tunnel Excavation	$1,728,454
Tunnel Lining	1,011,640
Conduit Excavation	324,760
Conduit Lining	1,799,489
Flume	7,500
Miscellaneous	260,000
Grand Total	$5,131,840

AQUEDUCT FOOTAGE TO JUNE 30, 1909

No.	Divisions	Canal	Tunnels		Conduit		Total Footage to be Accomplished				
			Excav.	Lining Sides	Excav.	Lining Invert	Tunnels	Conduit	Siphons	Flumes	Canal
2	Owens Valley	12982						111000			111200
3	Olancha							97000			
4	Rose Valley							64300			Sump Line 10558
5	Little Lake		3435		111		30300	18800	5280		
5-A	Grapevine		1831		100		10950	22000	4400		
5-A	Boulder		681		32		10050	900			
6	Freeman				700			103600	2782	2282	
7	Jawbone		45740	11739	25090	7445	59448	44717	13448	250	
8	Mojave				51272	40432		148750			
9-N	Antelope		4590		446						
9-S	Antelope-Howard		820		6322	3696	14878	101112	26909	270	
10	Elizabeth		10198				26860				
11	Saugus		21102	3019	7448	221	54040	11046	21158	1875	
	Feet	12982	88397	14758	91521	51794	206526	723225	73977	4677	121758
	Miles	2.45	16.74	2.80	17.33	9.81	39.11	137.16	14.01	.89	23.08

Total Excavation to June 30, 1909 .... 36.52 miles
Total Lining to June 30, 1909 .... 12.61 miles
Total Cover (Conduit) to June 30, 1909 .... 7.60 miles

TRANSPORTATION

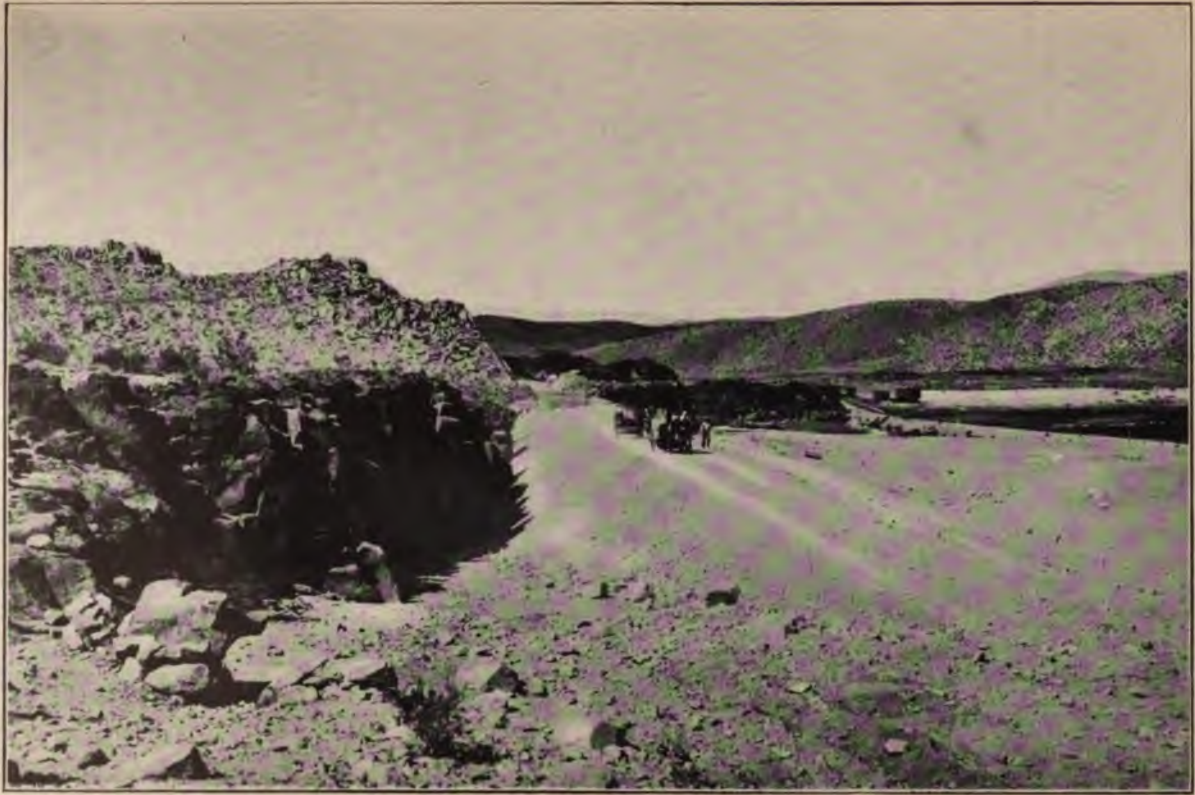
Facilities for the transportation of construction materials have been greatly improved during the last fiscal year. The California & Nevada Railway has been extended to Siding No. 24, a distance of 102 miles, thus serving all that portion of the located line from the Haiwee dam south as far as Mojave. Sidings have been placed at regular distances, and a daily passenger service to the end of track has been inaugurated.

The Red Rock Spur, 8.35 miles in length, running from Siding No. 6 to the head of the Red Rock Canyon, has been built by the Southern Pacific Railroad at cost plus a fixed percentage, and turned over to the City of Los Angeles for operation. This line is intended to handle all material necessary for the construction of the Freeeman Division, together with section No. 1 of the Jawbone Division, and has been equipped with suitable rolling stock, delivering tonnage at the upper terminus at a minimum rate of ton mile cost. Forty-one hundred and eighty-three ton miles were accomplished during the month of May. This figure will naturally be heavily increased during the coming year, owing to the operation of four steam shovels on the Freeman Division.

Wagon haulage from the railroad has been greatly facilitated by the employment of traction engines of the "caterpillar" type, a style peculiarly adapted to desert conditions. With a capacity of from five to fifteen tons, depending on the grade, these engines make regular trips to the various camps at an average ton mile cost of 25 cents. It is interesting to compare this figure with the lowest bid received for this work, namely, 80 cents per tone mile.

Ordinary wagon haul with teams is carried on in connection with the work of the traction engines, distributing the material to the tunnel portals and conduit construction camps at an average cost of 50 cents per ton mile. Roads have been constructed to all necessary points on easy grades, affording ready access to the work.

The problem of transportation, which bid fair to be the chief obstacle to the successful prosecution of construction, has been successfully combated and solved by the various methods employed; and, while constant supervision is necessary, the economical haulage of materials is now an accomplished fact.



CALIFORNIA & NEVADA RAILROAD, NEAR LITTLE LAKE

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

STATEMENT OF BUILDINGS IN USE ON THE LOS ANGELES AQUEDUCT

Bunk Houses, Cottages and Engineers' Residences	215
Blacksmith and Machine Shops	55
Tents	530
Transformer and Air Compressor Buildings at Tunnels	40
Barns, Stables and Hay Sheds	40
Warehouses and Storehouses	22
Office Buildings	17
Powder Houses and Magazines	20
Change Rooms	9
Saw Mills	5
Hospitals	6
Garages	2
Reading Rooms	3
Miscellaneous Buildings	32
Total	996

(This statement does not include main buildings of the cement mill or the hydro-electric power plant buildings.)

ROAD CONSTRUCTION

Div.		Miles
2	Owens	16
3	Olancha	12
4	Rose Valley	..
5	Little Lake	31
5-A	Grapevine and Boulder	33
6	Freeman	21
7	Jawbone	55
8	Mojave	33
9	Antelope	13
10	Elizabeth	8
11	Saugus	5
	Total	227

LENGTH OF RAILROADS BUILT AND OPERATED BY CITY

	Miles
Red Rock Spur (standard gauge)	8.35
Cement Plant Quarry R.R. (narrow gauge)	5.70

The Southern Pacific Railway Company has laid 100 miles of track on the railroad from Mojave north.

HYDROGRAPHIC WORK IN OWENS VALLEY

C. H. Lee

I herewith submit a statement of the work which I have been doing during the last six months and a summary of results obtained. Many of my investigations are still in progress, so that the results given are incomplete and not to be considered final.

In regard to hydrographic conditions since October 1, 1908, only general statements can be made, as computations of total flow are not made up by the Geological Survey until the end of the calendar year. Precipitation during the past winter has been above normal, perhaps 20%. The spring was cool and no marked change in stream flow occurred until early May, when discharges increased somewhat. About June 1, a series of warm days melted the snow very rapidly, resulting in high discharges which have continued during the month. The season's total run-off will probably be well above normal.

Pursuant with your instructions of June, 1908, I am making a general study of underground water supplies in Owens Valley with special reference to their use by the Aqueduct. My work so far has consisted in gathering the necessary data regarding characteristics and size of catchment area, precipitation, evaporation, hydrography, and hydrology, upon which computations of quantity can be based. Also the analyzing of samples of underground water for the purpose of determining its fitness for use.

CATCHMENT AREA

The portion of the Owens Valley covered by this study, lying between the crest of the Sierra and the Owens River, may in general be divided into three belts:

1. High mountains receiving precipitation in the form of snow and losing it only by direct evaporation or surface run-off.
2. Intermediate mountain faces and gravel alluvial slopes receiving precipitation in the form of rapidly melting snow or rain losing principally by seepage, thus forming a very important source of underground water.
3. Valley floor receiving precipitation principally as rain and losing it by surface run-off, seepage and evaporation. This area also loses seepage water from the alluvial slopes by evaporation from the soil.

The area of each of these hydrographic belts enters into computations for quantity of the underground supply. Boundaries of high mountain drainage basins are being obtained from existing maps; boundaries of areas feeding the underground supply and those losing by evaporation, from actual surveys and field sketches. At this date practically all of the valley floor has been mapped from Round Valley to Alabama Hills and the upper slopes and foothills from Tinemaha Point to Alabama Hills.

PRECIPITATION

Topographic conditions control precipitation in Owens Valley to such an extent that observations at points a few miles apart are very different. From south to north there is a gradual increase in precipitation, and from west to east a marked decrease. I have established 17 rain gauges near Independence, covering an area 25 miles long and 6 miles wide, with a range of elevation from 4,000 to almost 6,500 feet, for the purpose of studying these variations. Fifteen of these gauges are in the area between the base of mountains and the valley floor. The standard Weather Bureau gauge and system of measuring is used and observations have been made after every storm since October 1, 1908.

Summarizing the results, it may be said that the precipitation increases quite uniformly from the 4,000 to 6,000 foot levels and is about three times as great at the upper level as at the lower. The normal precipitation at the 6,000 foot level varies from about 9 inches at Bairs Creek to about 14 inches at Taboose Creek and at the 4,000 foot level from 3 inches to 6 inches. The average normal precipitation over the whole area from Georges Creek to Tinemaha Creek and the base of mountains to valley floor is about 8½ inches. As this area absorbs practically all the precipitation falling upon it, the addition to the underground supply from this source amounts to about 90 sec. ft. continuous flow.

In addition to these observations, a long range study of precipitation in the High Sierra is being made from published Weather Bureau records.

EVAPORATION

Evaporation losses may occur from snow, water or damp soil. The two latter are important in this study. To measure the evaporation from a water surface in this region, I have established two standard evaporating pans such as are used by the U. S. Reclamation Service, one at Black Rock Springs and the other in Owens River at Citrus Bridge. These are observed every four days, the former record commencing August 1, 1908. The full year's record will probably show a total of 60 inches, the period of highest rate being April 1 to September 1.

Evaporation from soil varies somewhat as does that from water, but in addition is influenced by depth of ground water surface and character of material through which water must be drawn by capillary action before evaporation can occur. I have been carrying on experiments near Independence since April 1, 1909, for the purpose of studying the effect of these various conditions upon evaporation from soil. Observations during the latter part of May and June show the following:

The evaporation from bare sand caked with alkali at the surface,—water level 1½ feet below the surface—is about 0.06 inches per day or 1-5 the rate from water for the same period; the evaporation from black adobe soil slightly caked with alkali, with a scattered growth of grass,—water level ½ foot below the surface—is about 0.18 inches or half that from water for the same period.

HYDROGRAPHY

The U. S. Geological Survey has for several years made measurements of stream flow from the Sierra at the upper edge of irrigated lands. There is a considerable seepage loss from stream channels between the mountains and this point, and also between this point and Owens River, which feeds the underground supply. The hydrographic work which I am carrying on consists of making comparative measurements to determine these losses, and also comparative measurements on Owens River to determine seepage gains.

Results of these measurements are as follows: seepage losses during the summer months between canyon mouth and U. S. G. S. stations vary on different streams from 25% to 50% of the total discharge, or at the rate of from 1.0 to 1.75 sec. ft. per mile of channel. This loss amounts in total to about 60 sec. ft. during four months of the year from regularly measured streams between Tinemaha Creek and Georges Creek, inclusive. Seepage losses during the winter months vary from 15% to 40%, or at the rate of from 0.30 to 0.75 sec. ft. per mile of channel. The loss in total amounts to about 20 sec. ft. for four months. The average loss from regularly measured streams above gaging stations is therefore about 40 sec. ft. continuous flow. The loss from small unmeasured streams is about 10 sec. ft. continuous flow. There is thus about 50 sec. ft. continuous flow between Tinemaha

Point and Alabama Hills which has not been previously recognized.

Seepage losses between U. S. G. S. stations and Owens River are also large. During eight months of almost every year, and also during the flood flow period of years below normal in precipitation, no flowing streams reach the river. Data of seepage losses during years above normal is not yet available.

Measurements of Owens River during the spring low water period indicate a gain of seepage between Charlie's Butte and Mt. Whitney Bridge of from 0.5 to 1.0 sec. ft. per mile.

HYDROLOGY

Underground water studies which I have carried on consist principally of observations of fluctuation of ground water levels in 27 wells and 142 two-inch diameter auger holes distributed over an area of about 70 square miles in the valley floor north and south of Independence; and classification and mapping of valley lands from Round Valley to Alabama Hills with regard to depth of ground water as indicated by natural vegetation and wells.

With the data at present available, it appears that under the floor of the valley there is a large area where the average depth of water, September 1, is about six feet. The surface of this ground water is subject to a periodic fluctuation in level, the crest occurring about April 1, and the trough about September 1, with an average range of three feet. Fluctuations of level are very slight in wells on the dry sandy slopes above the valley floor, except when near enough to the mountains to feel the effect of the winter's precipitation. Other data regarding hydrologic conditions is not yet available.

Computations from this data for quantity of the underground supply are to be based on the assumption that the Owens Valley fill is in a water-tight basin, is composed of gravel, sand and clay arranged more or less in layers, and contains water in the spaces between individual particles. Under natural conditions the yield from any portion of such an underground reservoir consists of: 1, the evaporation loss from the ground surface, including transpiration; 2, seepage into surface drainage channels; 3, net underflow from the basin. By development of artesian wells or pumping, part or all of this yield may be recovered, but the great mass of water filling the voids must remain undiminished in amount considered as an average.

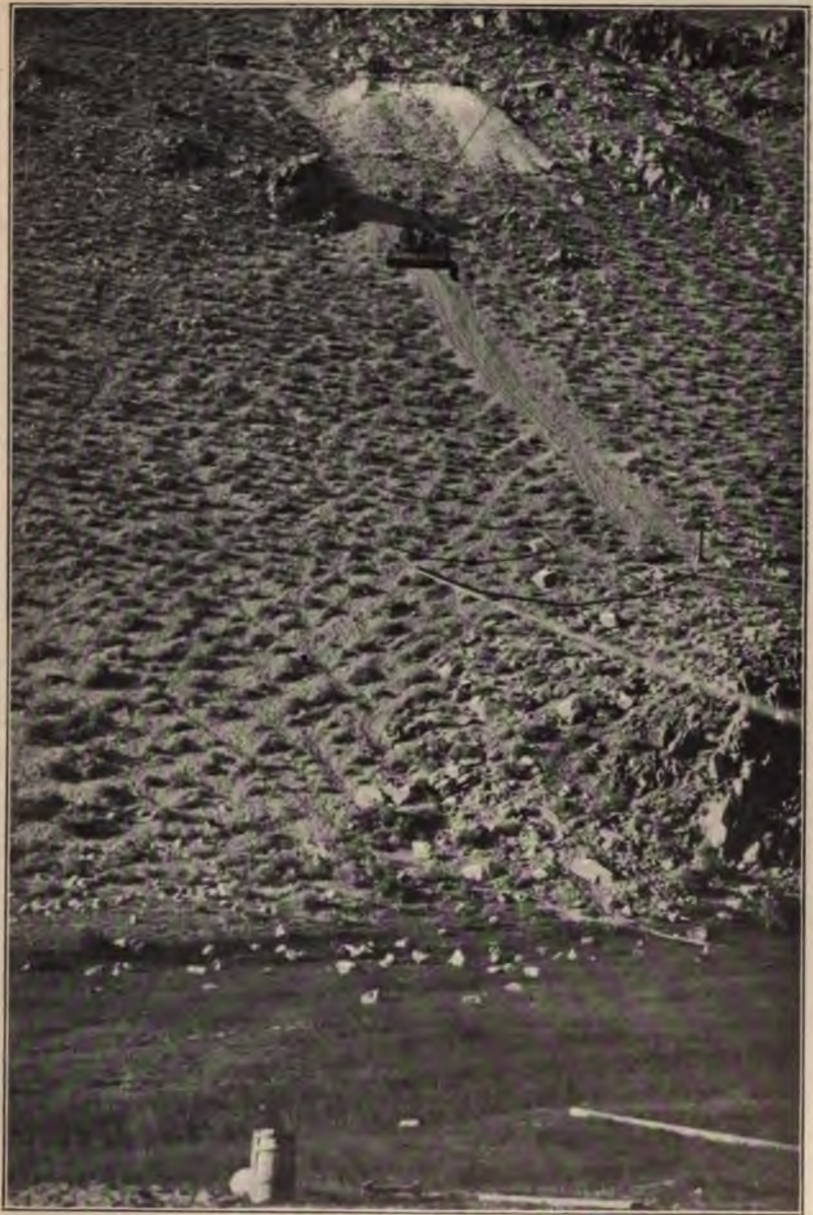
Under natural conditions without pumping or artesian flow, the yield is the difference between total additions to the reserve and total draft therefrom. Important among the former are: 1, precipitation on intermediate mountain faces and alluvial slopes; 2, seepage from channels and flood plains of small streams draining the Sierra Nevada between mouths of canyons and Owens River; 3, seepage from irrigation waters; 4, considering any portion of the valley, such as the basin from Tinemaha Point to Alabama Hills, the underflow entering the valley fill past Tinemaha Point. The draft is largely evaporation from ground surface, transpiration, seepage waters collected in the channel of Owens River, and the underflow through the valley fill past Alabama Hills. All of these elements are being measured and studied except the underflow, which is relatively small and very difficult of measurement. Data is not yet complete enough to make any computations, but it is instructive to note that normal precipitation, and seepage from stream channels absorbed by the alluvial deposits between the mountains and the valley floor, amount to about 140 sec. ft. continuous flow.

QUALITY OF WATER

Twelve samples of underground water have been submitted to F. M. Eaton, chemist, of Oakland, California, for the purpose of making quantitative chemical analysis for calcium, magnesium, sodium, sulphate, carbonate, bicarbonate and chlorine. Of these samples, two were from springs, six from shallow wells, and four from deep wells. The results showed a surprisingly small salt content for both shallow and deep wells when fed by water from the Sierra: shallow wells about 20 parts in 100,000 and deep wells about 15. The proportions of the various elements were quite uniform and were as follows: calcium, 12%; magnesium, 3%; sodium, 15%; sulphate radical, 15%; carbonate, 0%; bicarbonate, 50%; chlorine, 5%.

Both shallow and deep well waters fed from the Inyo Mountains were heavily charged with alkali salts and contain the elements in proportions different from that stated above.

As but an exceedingly small quantity of the waters of the Owens Valley is derived from this source, this fact has no significance as affecting the quality of the water yield of the valley.



AERIAL TRAMWAY IN SAND CANYON, GRAPEVINE DIVISION

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POWER DEVELOPMENT AND DISTRIBUTION

For Construction Purposes

Power Plants

Since the report of November, 1908, the Division Creek No. 2 hydro-electric plant of 600-K.W. capacity has been completed and has been in operation for several months, providing power for centrifugal dredges No. 1 and No. 2. The second unit of 750-K.W. capacity is just being installed in the Cottonwood Power House, thus completing the hydro-electric power plants as described in the last report.

Power Transmission Lines

The transmission lines of the Cottonwood Power System have been extended from Pinto to the cement plant, a distance of approximately 17 miles, and a bank of three 250-K.W. step-down transformers has been installed at the cement plant at a total cost of approximately $26,000. This makes a total of 205 miles of 33,000 volt transmission lines. The Division Creek and Cottonwood power plants are now running in parallel, furnishing power from the intake to Pinto for construction work and at the same time delivering approximately 400 K.W. to the cement plant, thus bringing about a saving of approximately $100 per day in fuel oil, as well as adding to the reliability of both power systems. This means that the total cost of this extension and installation at the cement plant will be equaled in fuel oil in 260 days and that a corresponding net saving will result thereafter. As stated in the former report, the hydro-electric plants are no greater than is necessary for reliability for the other construction work, but are sufficient to furnish excess power, varying from nothing to a maximum, but averaging not less than 400 K.W. to the cement plant. The second unit at Cottonwood provides for additional load along the line.

The Saugus power transmission system has been extended from the Soledad Canyon south to the end of the Fernando Tunnel, making approximately ten miles additional, or twenty-six miles of transmission line in this section.

Transformer Stations

There are at present 24 step-down transformer stations installed along the total of 205 miles of power transmission line, varying in capacity from 80 K.W. to 750 K.W., the large majority being but 80 K.W. Equipment for eight additional transformer stations is now ordered to provide for additional plants at tunnel stations and for electric shovels.

TELEPHONE SYSTEM

Telephone Lines

Since the report of November last, the main telephone line from Los Angeles to Owens Valley has been extended approximately ten miles, from near Independence to the intake, making an approximate length of 240 miles. Local telephone systems have been erected in the Antelope Valley, the Grapevine, Boulder Peak and the Little Lake Divisions and a local system is now being erected in the Freeman Division, which will soon be completed, making in all 165 miles of local telephone lines, about one-half of which are on the main line poles and one-half on independent poles. This is an addition of approximately 80 miles of local telephone lines since the last report.

Telephone Stations

There are now connected to the main line twenty-two 2500-ohm 5-bar long distance telephone stations. The local systems have in all 98 telephone stations at the present time, the instruments used being the same as those on the main line, so that by switching in one of the local systems on to the main line, through conversation may be provided for.

CEMENT PLANT

The camp at the cement mill has developed into a permanent town. It was at first given the name "Aqueduct," which has been changed to Monolith Railroad Station, although the postal name is still Aqueduct.

In addition to the mill structures proper, there are fifteen buildings, including a small hospital, a reading and chapel hall, dormitories, mess hall and several houses rented to employes, as well as a general merchandise store. All the buildings except the store were erected and are owned by the city.

Details of the cement plant and process were given in the Third Annual Report, so that at this time it is only necessary to briefly mention recent developments in connection with the cement project.

The building contractor completed the buildings for housing the already installed cement making machinery February 24, 1909.

One kiln was fired up March 8, and the manufacture of cement was commenced. The plant has been in continuous operation from that time to date, although it has not been operated to its capacity on account of the quarry development, clay supply and mill construction not having been advanced enough to meet its full requirements.

During the last three months the shipments of cement have amounted to 30,000 barrels and the rate of shipment is being increased to meet the requirements of construction work along the Aqueduct. Both laboratory tests and its use in construction work have proved the cement to be of good quality, meeting the requirements of the engineers, and safe for the important construction for which it is manufactured.

LIMESTONE

A limestone quarry has been opened at the upper terminal of the cableway, and development work has advanced sufficiently to enable the quarry gang hereafter to meet the requirements of the cement mill in quantities delivered. The limestone has been satisfactory in both quality and uniformity.

Two buildings have been erected at the quarry for dormitories and mess hall, and two miles of two-inch pipe have been laid to secure a satisfactory supply of water for this camp.

The Leschen aerial tramway was completed January 15, 1909, and has thus far met all requirements in transporting rock from the quarry to the terminal of the narrow gauge railroad.

The narrow gauge railroad, seven miles long from the terminal of the quarry cableway to the cement mill, was completed December 17, 1908, and has been maintained in good condition. It has been equipped with a locomotive and twelve cars for hauling limestone to the mill, and is kept in daily operation.

CLAY

Title to the clay deposit was granted by the Government on the last day of the Roosevelt administration.

The excessive rainfall of the past winter flooded the clay deposit to an almost unprecedented height, making it impossible to excavate clay by ordinary methods. When the stock of stored dry clay at the mill became exhausted, resort was had to an extensive deposit of tufa rock located just north of the cement plant. This rock was used with good success instead of the clay in making cement, and this deposit has proved to be a valuable asset of the cement project.

An electrically driven dredge has recently been completed, and commenced excavating clay which is being transported by the aerial tramway to the cement mill. This method of excavating clay is the cheapest and surest; excessive rainfalls cannot interfere with its operation.

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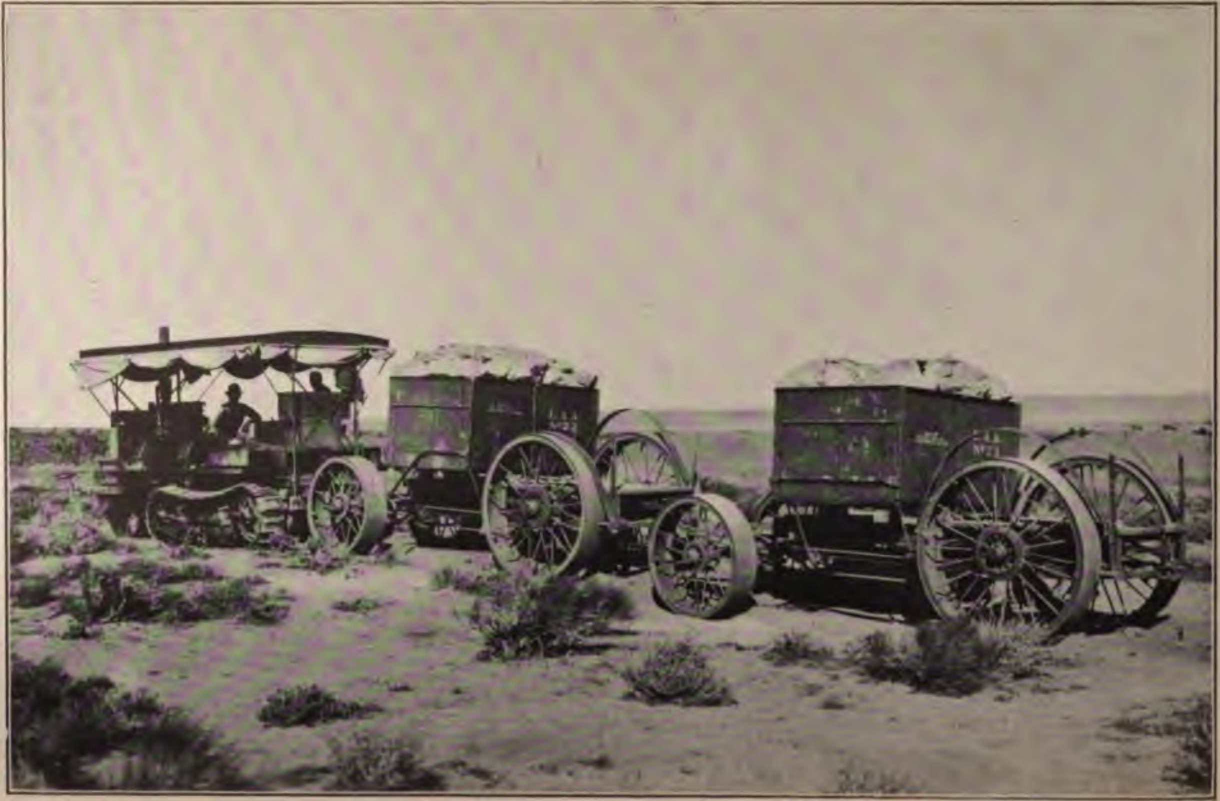

TRACTION ENGINE HAULING ROCK IN MOJAVE DIVISION

Annual Report Store Department
LOS ANGELES AQUEDUCT

STATEMENT OF PURCHASES

From December 1, 1908, to June 30, 1909.

July 6, 1909.

HONORABLE BOARD OF PUBLIC WORKS,
Los Angeles, California.

Gentlemen:—Herewith I beg to hand you report of the Store Department for seven months, beginning December 1, 1908, and ending June 30, 1909, in accordance with instructions from your Honorable Board.

Yours very truly,
W. R. ORMSBY, Storekeeper.

Showing complete list of items and quantities of each item and cost purchased by the Board of Public Works for use upon the Aqueduct. All articles of subsistence are embraced under that general head, showing the gross cost; machinery covers all items that can be construed, showing the gross cost; tools, axes, hammers, saws, shovels, picks, etc., etc., by number; nails, bolts, steel, iron, hay, grain, etc., by hundred weight or ton; lumber per thousand feet; all expendable items are reported in red.

Class "A"—Tools, Carpenter, Blacksmith, etc.
Class "B"—Machinery, Renewals and Repairs.
Class "C"—Construction Material and Supplies.
Class "D"—Electrical Equipment and Supplies.
Class "E"—Oil, Waste, etc.
Class "F"—Office Equipment and Furnishings.
Class "G"—Transportation Equipment and Supplies.
Class "H"—Cook and Bunk House Equipment.
Class "I"—Miscellaneous.

CLASS "A"

Tools

Items	Unit	Amount
"Jim" Crows	8	$ 108.00
Wheelbarrows	242	1,097.18
Wheelbarrow Repairs and Renewals		10.20
Spirit Levels	282	348.23
Tongs	184	147.10
Clevises	21½ lbs.	1.18
Sows, Blacksmith	2	6.00
Vises	57	433.22
Tri-squares and Bevels	287	116.32
Carpenter Rules and Pencils		11.28
Tamping Sticks	58 1/6 doz.	303.37
Pliers, Pincers, etc.	559	253.01
Steel and Wood Chisels	52¼ doz.	257.07
Hack Saws, Frames and Blades		498.16
Blowers	20	1,663.80
Blower Fixings and Renewals		3.65
Hardies, Fullers, Flatters, Swedges, etc.	1,592.62 lbs.	171.91
Warehouse Trucks	22	157.20
Reamers	52	27.45
Knives, Draw, Farriers	143	73.95
Glass Cutters	12	.75
Pinch, Claw and Crow Bars	106	67.51
Building Papers, Caps and Tacks		196.30
Oil and Whet Stones	29 doz.	16.43
Grind Stones	12	45.00
Grind Stone Repairs and Renewals		.50
Hoes	24 doz.	123.15
Anvils	3,482 lbs.	340.29
Packing Tools		13.80
Pipe Cutters)		
Pipe Cutter Renewals)		116.05
Jacks and Jack Screws	66	365.10
Nails	175,239 lbs.	4,561.96
Spikes	15,958 lbs.	493.71
Files	639½ doz.	1,207.06
Files, Brushes and Cleaners	168	33.65
Hatchets and Axes	59 1/6 doz.	391.48
Mattocks	10 doz.	46.38
Hammers	2,445	862.80
Steel, Drill, Pick, Spring and Tool	67,391.56 lbs.	3,291.35
Steel, Sheet	44,102.5 lbs.	1,314.10
Shovels	328 11/12 doz.	2,932.93
Picks	268 5/6 doz.	1,001.66
Sprinkling Cans)		
Brushes, Brooms, etc.)		391.94
Hand Drills	57	307.65
Drills	1,577	842.08
Braces	118	131.63

Items	Unit	Amount
Bits	663	307.63
Augers	80	119.76
Emery Wheel Dressers	3	1.40
Plumb Bobs	23 $^{5}/_{6}$ doz.	178.63
Funnels	522	501.93
Handles, Hammer, Pick, Axe, etc	1,136½ doz.	1,586.96
Punches) Belting, Lacing and Dressing)		4,673.93
Wrenches	2,099	1,616.81
Ratchets	35	178.39
Pocket Tapes) Pocket Tape Repairs and Renewals)		1,007.11
Transits	14	2,854.00
Transit Repairs and Renewals		118.65
Levels	21	1,704.30
Level, Range and Stadia Rods	61	265.08
Chain Pins	6 sets	6.60
Stocks, Dies, Taps and Screw Plates		1,448.43
Melting Ladles	38	27.44
Melting Pots	40	184.75
Torches	64	237.10
Forges	21	513.05
Screw Drivers	563	159.04
Graphite	372 lbs.	70.65
Welding Compound	2,620 lbs.	150.72
Borax	2,607 lbs.	134.53
Resin	755 lbs.	20.77
Emery Dust Paper and Cloth		60.44
Sand Paper	5,568 sheets	46.27
Trowels	30 doz.	216.83
Lines, Plumb and Chalk	359 $^{5}/_{6}$ doz.	129.01
Ladders	10	24.74
Cap Crimpers	127	69.30
Tools) Solder and Supplies)		694.68
Lumber Crayon and Carpenters Chalk	867 $^{1}/_{3}$ doz.	132.70
Forks, Pitch and Manure	15 $^{2}/_{3}$ doz.	87.34
Saws	634	970.97
Sledges	99	58.12
Shears, Tinners, etc	190	220.99
Drill Sockets	8	4.29
Carry and Cant Hooks	15	15.50
Beam Compasses	1	5.13
Planimeters	2	61.48
Brass	112.31 lbs.	28.43
Rakes	16	7.44
Scythes	1	1.19
Branding Irons	246	45.00
Mica	5 lbs.	2.50
Planes	75	65.13

Items	Unit	Amount
Paper Bags	12,350	20.51
Plane Table Repairs and Renewals		9.00
Gypsum	373.65 tons	978.65
Adzes	18	16.80
Oakum	10 lbs.	.35
Tools, Miscellaneous		294.37
Total		$47,118.40

CLASS "B"

Machinery, Renewals and Repairs

Gas Engines	5	$ 2,905.00
Gas Engine Repairs and Renewals		483.50
Well Digging Machines	2	218.90
Well Digging Machine Repairs & Renewals		844.30
Fifth Wheel Platforms	9	277.50
Transformer Floats and Trucks	2	540.00
Car Movers	1	4.50
Rock Drills	64	10,306.35
Rock Drill Repairs and Renewals		22,856.84
Oilers and Oil Cans	854	180.21
Oil and Grease Cups	250	91.90
Scrapers	76	1,373.20
Scraper Repairs and Renewals		220.82
Plows	3	139.95
Plow Repairs and Renewals		162.21
Chain	6,818 lbs.	357.36
Injectors	1	10.80
Machine Shop Renewals		185.72
Bucket and Gasket Cutters	9	74.70
Air Compressors	1	275.00
Air Compressor Repairs and Renewals		606.64
Pulleys	274	838.14
Oil Gates	3	7.55
Concrete Mixers	28	22,961.00
Concrete Mixer Repairs and Renewals		732.28
Pumps	39	8,104.97
Pump Repairs and Renewals		821.41
Shafting	19,093.2 lbs.	472.53
Shafting Collars, Hangers, etc.		249.19
Gaskets	36 doz.	1.77
Truck Bearings	1	15.00
Excavator Repairs and Renewals		905.27
Locomotives (Steam)	1	1,883.00
Locomotive Repairs and Renewals		1,208.98
Cocks, Stop, Outlet, etc	927	742.69
Dredge Fittings		3,875.99
Steam Shovels	2	13.400.00
Steam Shovel Repairs and Renewals		646.25
Electric Shovel Repairs and Renewals		267.30

Items	Unit	Amount
Steam Engine Repairs and Renewals......		1,044.12
Flanges (Misc'l)	47	88.56
Water Wheel	1	4,500.00
Water Wheel Repairs and Renewals.......		120.75
Blasting Machine	1	24.00
Pipe Threading Machine..................	1	12.50
Gears and Bearings.......................	5	20.80
Oil Burners..............................	8	397.00
Oil Burner Fittings.......................		67.66
Gauges and Fittings......................		77.72
Lathes	4	1,582.68
Lathe Repairs and Renewals...............		14.00
Steam Hammers...........................	1	1,115.00
Drill Presses.............................	5	456.00
Emery Wheels and Grinders...............	21	557.13
Band Saws	5	488.69
Circular Saws............................	19	122.31
Cultivators	1	55.00
Planters	1	110.00
Seed	39 lbs.	5.72
Harrows	2	47.65
Hay Rake Repairs and Renewals...........		20.20
Mower Repairs and Renewals.............		66.83
Power Press	1	490.00
Power Press Repairs and Renewals........		10.65
Saw Tables..............................	4	3.20
Whistles	2	10.06
Sprocket Wheels.........................	41	109.45
Chain Links..............................	1,020	19.61
Elevators	4	862.00
Elevator Repairs and Renewals...........		76.40
Cement Plant Repairs and Renewals.......		2,628.88
Comptometers	1	200.00
Pinions, Gears, etc.......................	23 sets	251.63
Rock Crushers...........................	3	2,100.00
Rock Crusher Repairs and Renewals......		125.00
Drill Sharpener Repairs and Renewals.....		67.00
Traction Engines	7	26,250.00
Traction Engine Repairs and Renewals....		1,121.19
Combined Punch and Shears..............	1	50.00
Tire Shrinker............................	1	17.75
Boiler Repairs and Renewals..............		122.44
Jackson Hay Forks.......................	1	6.26
Miscellaneous Machine Renewals..........		379.41
Cars	284	22,023.00
Car Repairs and Renewals................		50.00
Car Wheels and Repairs..................		1,798.60
Total................................		$168,965.57

CLASS "C"

Construction Material and Supplies

Items	Unit	Amount
Lumber	8,609,698.73 ft.	$141,860.89
Windows, Doors and Sash		2,657.34
Ties	112,384	1,719.42
Lath	152 bdls.	40.04
Shingles	104,000	233.80
Lagging	101,888 ft.	1,545.47
Wedges	542,987	4,020.72
Sash and Door Fittings		129.18
Iron, "T"	26,747 lbs.	424.07
Iron, Angle	19,357 lbs.	458.55
Iron, Strap and Round	106.31 tons	5,197.78
Iron, Sheet	181,405.88 sq. ft.	9,347.95
Soft Steel	1,288,600.36 lbs.	22,984.55
Screw, Cap Set and Machine	5,373	79.86
Screws, Lag	15,419	172.17
Screws, Wood	16,075.33 doz.	268.34
Valves, Gate, Globe, Angle, Check, etc.	3,865	3,395.87
Bolts	218,401	3,212.87
Bolts, "U" and Plates	2,298	269.62
Bolts, "I"	99	17.10
Cotters	7,216	12.70
Rivets and Burrs	14,741½ lbs.	283.48
Washers	13,503½ lbs.	514.81
Nuts	19,470.6 lbs.	1,048.83
Blasting Powder and Explosives	903,000 lbs.	91,445.00
Fuse	384 cases	8,674.31
Caps	253,200	3,231.70
Cap Protectors	95,000	620.25
Blocks	297	581.02
Axles, Steel	50	109.30
Rope, Manila	6,558 lbs.	601.37
Rope, Steel	10,424 ft.	1,132.78
Cable	11,004 ft.	970.79
Hasps	760	38.59
Drawer and Door Pulls	486	11.56
Hooks and Eyes	271	.87
Staples	751 lbs.	23.63
Watering Troughs	26	257.20
Turn Buckles	160	59.72
Fire Brick	102,075	309.05
Fire Clay	4,750 lbs.	21.63
Spouts, Iron	7	201.25
Paint, Dry	3,866 lbs.	159.49
Paint, Mixed	1,136.87 gals.	838.67
Paint and Whitewash Brushes	503	218.26
Poles	3,080	5,612.61
Wire	826,494 ft.	3,706.22

Items	Unit	Amount
Wire	188,877.76 lbs.	29,304.42
Reels	57	843.00
Cable and Wire Rope Fittings		141.75
Asbestos, Gasket, Cover, Cement, etc.		136.48
Mag. Boiler Covering	600 ft.	48.00
Lanterns) Globes and Wicks)		390.03
Measures, Utility	33 1/3 doz.	52.66
Putty and Glass		64.80
Asphaltum	90 gals.	15.00
Tanks, Water, Air and Oil	73	4,438.55
Rubber Hose and Fittings		5,245.04
Pails and Buckets	111 5/6 doz.	372.67
Roofing and Building Paper	986½ rolls	1,681.99
Waterproof Paper	847,000 ft.	581.20
Tar Paper	270,000 ft.	277.00
Hinges	1,716	279.00
Tents	344	12,105.00
Stretchers, Fittings and Renewals		343.08
Candles	1,800 cases	8,000.00
Candle Holders	32	87.50
Sheet Tin	317 sheets	27.81
Sheet Lead	311 lbs.	27.16
Sheet Copper	279 lbs.	68.90
Spelter and Pig Lead	3,688 lbs.	189.74
Babbitt	495 lbs.	294.12
Sacks, Gypsum and Cement	60,840	6,382.00
Sacks, Sugar	4,000	150.00
Cement	31,425 bbls.	56,962.02
Cement Covers	140	1,196.20
Barrels, Water and Oil	325	877.54
Ore Bin Shutes and Gates	8	293.50
Sewer Tile	5,015 ft.	285.37
Terra Cotta Pipe and Fittings	288 ft.	60.84
Tallow Pots	13	10.62
Tar	104 gals.	10.65
Rails	381½ tons	15,759.46
Rail Fittings		2,208.89
Concrete Carts	62	1,272.00
Concrete Cart Repairs and Renewals		52.50
Glue Pots) Glue)		48.36
Window Fastenings		20.05
Locks) Padlocks, Keys and Sets)	2,255	983.87
Butts and Thimbles	1,821	103.20
Wire Netting and Screen		1,873.60
Wire Fabric	1,789,848.98 sq. ft.	26,215.09
Pipe	539,182.1 ft.	38,128.52
Pipe Fittings		5,108.76

Items	Unit	Amount
Casings and Fittings		20,227.60
Cross Arms	3,044	807.55
Cross Arm Braces	1,700	202.30
Fire Extinguishers	48	70.75
Tunnel Forms	73	1,894.45
Hard Rubber and Vulc. Fibre		26.09
Dowell Pins	8,200	90.25
Derrick		46.00
Bale Ties	219	284.70
Pebbles		328.92
Brads	13 lbs.	.68
Barbed Wire	4,264 lbs.	124.80
Bridge Material		128.95
"I" Beams	28	26.10
Miscellaneous Hardware		131.27
Shaft Cage	1	50.00
Lime	399 bbls.	507.15
Tramway Fixings		19.65
Manhole Covers—Rings and Steps		462.82
Total		$567,769.65

CLASS "D"

Electrical Equipment and Supplies

Items	Unit	Amount
Transformers	49	$ 17,364.13
Ammeters	7	164.80
Wattmeters	37	2,108.53
Volt-Amp-Meters	15	42.75
Controller	1	50.00
Motors	59	10,495.23
Motor Repairs and Renewals		576.88
Electrical Supplies, etc		4,963.88
Indicating Cartridge Fuses	1,900	117.14
Rubber Bushings	1,000	3.88
Receptacles—Synchronizing	2	2.58
Receptacles—Potential	503	111.74
Return Bends	233	23.32
Telephone Fittings and Renewals		1,691.96
Telephone Exchange Renewals		20.40
Wiring Cord	8,000 ft	99.51
Wiring Tape	1,270.5 lbs.	679.75
Insulating Tubing	1,300 tubes	45.30
Insulators	32,600	1,357.24
Elect. Lamps, Globes, Shades, etc		3,201.64
Test Sets	12	138.00
Switch Boards	78	1,146.62
Dynamos	4	6,481.55
Dynamo Repairs and Renewals		8.00
Carbons	400	13.80
Wire Moulding and Caps	2,000 ft.	30.00

Items	Unit	Amount
Switches and Fittings	295	2,064.47
Electric Hoists	10	2,828.40
Electric Hoist Repairs and Renewals		106.23
Electric Locomotives	4	5,723.30
Electric Locomotive Repairs and Renewals.		633.31
Transformer House Frame (Steel)	1	240.00
Auto Starters	4	518.65
Sash Cord	131 lbs.	19.36
Power Plant		103.05
Trolley Hangers	1,124	283.56
Trolley Wheels	18	12.15
Trolley Material		520.80
Total		$63,981.91

CLASS "E"

Oil, Waste, etc.

Oil, Lubricating	431.8 bbls.	$ 6,350.12
Oil, Fuel and Illuminating	48,882.84 bbls.	40,705.52
Grease, Lubricating	16,647 lbs.	1,132.90
Distillate	48,459½ gals.	3,901.38
Packing	1,021.23 lbs.	879.10
Waste	9,011 lbs.	632.36
Oil Filters	1	29.00
Total		$53,630.38

CLASS "F"

Office Equipment and Furnishings

Office Safe	1	$ 150.00
Office Furnishings		2,329.76
Office Desks	14	320.55
Adding Machine	1	475.00
Adding Machine Repairs and Renewals		3.76
Boxes, Empty	23 1/3 doz.	36.70
Wrapping Paper and Cutter	1,173 lbs.	49.51
Rubber Stamps)		
Stationery, Stamps, Paper, etc.)		6,257.67
Telephone Moving		13.00
Marking Pots		2.62
Stencils)		
Ink and Brushes)		25.62
Lamps)		
Chimneys)		596.84
Stools, Office and Drafting		25.65
Twine	3,466½ lbs.	279.62
Watches and Clocks	5	27.00
Tanks	1	3.25
Typewriters	21	1,777.47
Typewriter Repairs and Renewals		13.92

Items	Unit	Amount
Numbering Machines	4	41.80
Numbering Machine Repairs and Renewals.		.90
Bags, Leather	37	63.27
Bags, Mail	40	132.05
Total		$12,625.96

CLASS "G"

Transportation Equipment and Supplies

Items	Unit	Amount
Autos	1	$ 3,955.00
Auto Repairs and Renewals		1,569.46
Motorcycle Repairs and Renewals		123.54
Whips, Cushions, etc	453	295.90
Saddles, Bridles, etc	74	725.38
Brushes)		
Curry Combs)	33 1/3 doz.	93.58
Wagons and Carts	140	23,660.26
Wagon and Cart Repairs and Renewals		1,208.08
Wagon Jacks	25	59.30
Saddle Bags	5	17.25
Toe Calks and Calk Steel	1,263 lbs.	58.54
Mule and Horse Shoes and Nails		978.41
Lumber, Wagon Repairs	21,713 ft.	361.25
Blankets and Oiled Covers	103	446.16
Harness Repairs and Renewals		8,077.35
Horses	55	6,500.00
Mules	140	26,910.00
Buggies and Carriages	7	750.30
Total		$75,786.76

CLASS "H"

Cook and Bunk House Equipment

Items	Unit	Amount
Cook House, Commissary, etc		$10,116.00
Cots	849	2,489.80
Hay	937.58 tons	13,908.26
Salt	3,961 lbs.	28.69
Grain	1,264,031 lbs.	19,610.23
Coal	1,157.51 tons	11,006.22
Stoves)		
Pipe and Fittings)		1,080.25
Tile, Roof and Chimney	515 ft.	85.86
Sinks, W. Closets, Tubs and Boilers)		
Fittings)		454.59
Camp Chairs	224	160.19
Wash Bowls	51 doz.	82.42
Fire Wood	64 cords	309.00
Water Bags and Canteens	1,754	1,218.38
Folding Tables	18	40.50

Items	Unit	Amount
Bunk House Equipment		883.79
Water Jars	29	20.80
Scales	41	529.13
Total		$62,024.11

CLASS "I"

Miscellaneous

Items	Unit	Amount
Printing		$ 3,531.09
Expenses		1,579.42
Horse Medicine		474.74
Drugs and Medicine		646.41
Books, Maps and Signs		816.81
Cloth	2,480 rolls	356.45
Rubber Boots and Slickers	129	351.39
Cartage		131.95
Glass Bottles and Corks	104	3.12
Laboratory Supplies		697.34
Fees, Recording		42.40
Rentals		26,179.25
Certificates of Title	27	1,026.00
Surgical Instruments		79.22
Transportation Charges		696.90
Express Charges		72.51
Labor		655.80
Duck	202 yds.	38.57
Advertising		5.25
Miscellaneous Merchandise		2,272.62
Telephone Service		544.30
Telegraph Service		18.51
Blacksmith Work		546.65
Towel Supply		43.82
Photographs		67.10
Surveyor—Lumber		147.00
Water Supply		676.00
Traverse Table	1	1.75
Total		$41,702.37

RECAPITULATION

Class "A"—Tools, Carpenter, Blacksmith, etc.	$ 47,118.40
Class "B"—Machinery, Renewals and Repairs	168,965.57
Class "C"—Construction Material and Supplies	567,769.65
Class "D"—Electrical Equipment and Supplies	63,981.91
Class "E"—Oil, Waste, etc.	53,630.38
Class "F"—Office Equipment and Furnishings	12,625.96
Class "G"—Transportation Equipment and Supplies	75,786.76
Class "H"—Cook and Bunk House Equipment	62,024.11
Class "I" —Miscellaneous	41,702.37
GRAND TOTAL	$1,093,605.11

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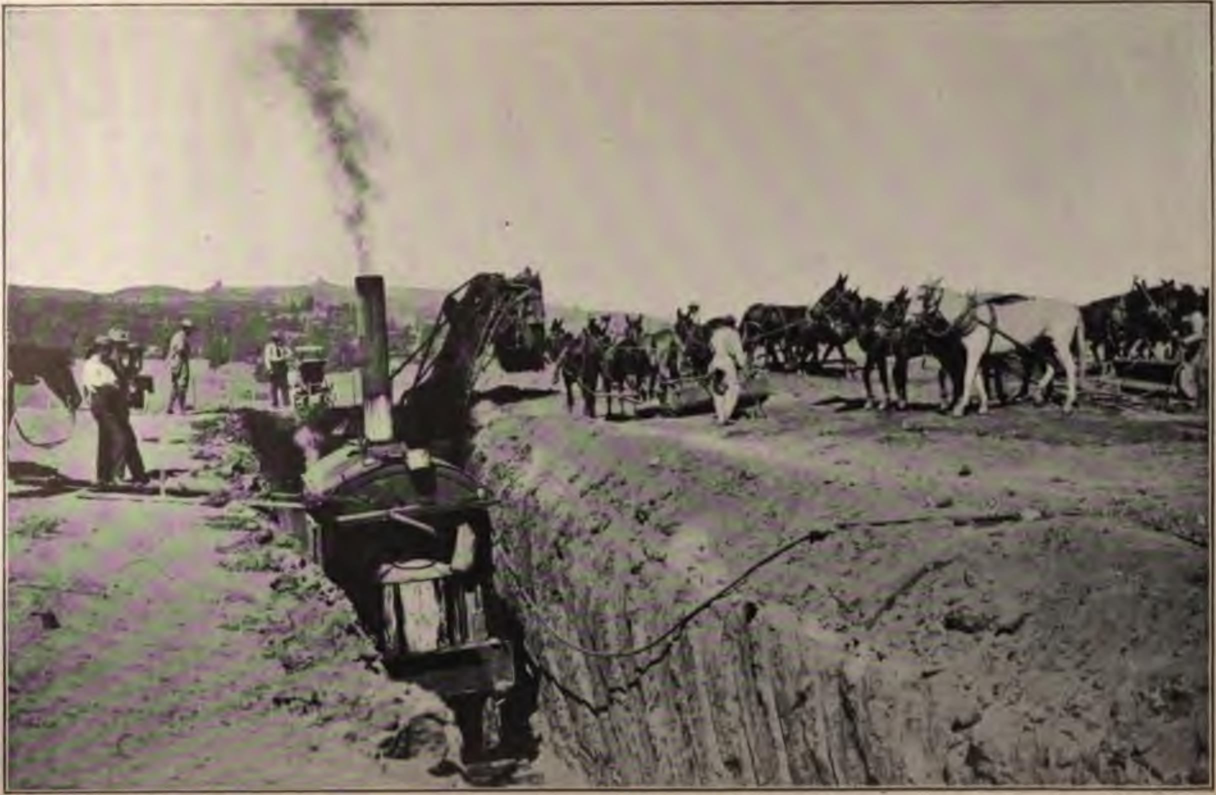

NO. 40 STEAM SHOVEL IN OPERATION ON HOWARD CONTRACT, ANTELOPE DIVISION

Annual Report of Accounting Dept.

LOS ANGELES AQUEDUCT

CITY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
FOURTH ANNUAL REPORT
FOR THE PERIOD ENDING JUNE 30, 1909

Honorable Board of Public Works,
City of Los Angeles.

Gentlemen: I herewith transmit to you the Fourth Annual Report of the Accounting Department of the Bureau of the Los Angeles Aqueduct, for the period ending June 30, 1909.

On account of the remote and inaccessible locality in which much of the work is being prosecuted, it is not possible to obtain and assemble data necessary to admit a closing of the accounts of this Department until the 15th of the month; therefore, it is only possible to present to you in this report the total expenditures to the close of May 31, 1909. The statement of Cash Transactions, however, is complete to date of June 30, 1909.

W. M. NELSON,
DISBURSING AGENT
AND CHIEF ACCOUNTING OFFICER

ORGANIZATION

The Accounting Department of the Los Angeles Aqueduct is organized along the lines of the best known railway practice, and for the information of all who may be interested, a brief outline of the organization is here given.

The Disbursing Agent and Chief Accounting Officer has charge of all the accounting, both in the general office and field, all departments reporting to his office on such matters. Construction Clerks in the field are responsible to him for the proper accounting of materials, supplies and equipment; also keeping of time and reporting same; preparation of pay rolls and distribution of labor. The Disbursing Agent has surrounded the accounting with documents and forms necessary for the proper protection of all concerned, and while it is known that the preparation and care of these forms is rather difficult at times, they are deemed necessary from various standpoints, the principal one being that they save letter writing.

It must be realized that the municipal accounting which is governed by charter and ordinance provisions must be handled to the satisfaction of officers in authority. An effort is being made to handle the accounting of the Los Angeles Aqueduct in a complete and proficient manner so that all records may be provided with proper authorization, with the end in view that the most thorough accuracy be secured, and the most rigid investigation is always welcome.

To simplify matters in the Accounting Department of the General Office, the work has been divided into what is known as Bureaus (all under a Chief Clerk, reporting to Disbursing Agent), they being set forth in the following Schedule, showing in a brief general way the duties pertaining to each bureau:

Bureau of Payments

This Bureau has charge of all disbursements, whether by voucher or pay checks.

Pay Roll Bureau

This Bureau has charge of the auditing of all pay rolls, and is responsible for all documents and papers in connection therewith. It is also responsible for the care of all assignments.

Bill and Voucher Bureau

This Bureau has charge of all purchase bills, contracts and all documents pertaining thereto. Vouchers are prepared by this Bureau, also all bills collectible.

Registry Bureau

The Registry Bureau has charge of the general books, and all registers pertaining to the accounting, also preparation of exhibits as to cost, etc.

ACCUMULATIVE STATEMENT OF RECEIPTS AND DISBURSEMENTS FROM NOVEMBER 30, 1906, TO JUNE 30, 1909

Cash on Hand, November 30, 1906		$ 621,693.45	

RECEIPTS

Advances	$ 57,166.40		
Bills Collectible	27,943.83		
Refunds	11,611.82		
Sale of Bonds	7,991,011.61		
Total Receipts		$8,087,733.66	
Total Receipts and Cash on Hand			$8,709,427.11

DISBURSEMENTS

Bills Payable (Advances refunded to Water Department)	$ 57,000.00		
Pay Rolls	2,320,912.30		
Material, Supplies and Equipment	2,713,764.17		
Services and Miscel. Expense	396,001.42		
Freight and Express	319,904.98		
Construction Contract	19,001.15		
R. of W., Land & Water Rights	785,407.53		
Transferred to Interest and Sinking Fund	4,076.61		
Refund Vouchers	145.33		
Discounts Refunded	89.39		
Interest on Liabilities	275.00		
Taxes	15,301.36		
Total Disbursements		$6,631,879.24	
Cash on Hand, June 30, 1909		2,077,547.87	
Total Disbursements and Cash on Hand			$8,709,427.11

CASH TRANSACTIONS FOR PERIOD BEGINNING NOVEMBER 30, 1908, AND ENDING JUNE 30, 1909

Cash on Hand, November 30, 1908		$1,222,608.70	

RECEIPTS

Bills Collectible	$ 18,824.61		
Sale of Bonds	4,898,240.00		
Bills Payable			
Total Receipts		$4,917,064.61	
Total Receipts and Cash on Hand			$6,139,673.31

DISBURSEMENTS

Pay Rolls	$1,640,803.27	
Material and Supplies	1,789,521.14	
Service & Miscel. Expense	135,665.92	
Freight and Express	283,865.75	
Construction Contract	19,001.15	
Right of Way, Land and Water Rights	193,132.49	
Discounts Refunded	135.72	
Total Disbursements		$4,062,125.44
Total Cash on Hand, June 30, 1909		2,077,547.87
Total Disbursements and Cash and Hand		$6,139,673.31

STATEMENT OF FLOATING LIABILITIES, JUNE 30, 1909

OUTSTANDING BILLS AND CONTRACTS Contracts and ordinary Purchase Bills for which bills have been rendered, but not vouchered.	$ 98,882.71
OUTSTANDING VOUCHERS Contracts and Purchase Bills for which bills have been received and vouchered, but not paid.	293,863.48
UNPAID WAGES Outstanding Time Vouchers, Pay Checks, Apportionment Checks and June Pay Rolls.	352,939.46
TOTAL	$745,685.65

The following financial exhibit, with its explanations, etc., is intended to convey to the Tax Payers of the City of Los Angeles just how much money has been received through the sale of bonds, or otherwise, and just what has been spent from the inception of the project to May 31, 1909:

SALE OF BONDS, 1905 The major part of this money was used for the purpose of preliminary investigation work, engineering, etc., the balance merging into construction work.	$1,516,166.33
SALE OF BONDS, 1907-08-09	7,991,016.61
MISCELLANEOUS COLLECTIONS This account represents the collection of various refunds, small bills, etc., not creditable to any definite account.	1,665.90
MISCELLANEOUS RENTALS This account represents the various amounts collected for *rental* of land and property owned by the Aqueduct.	2,672.99

DISCOUNTS This account represents discount allowed the city for prompt payment of purchase bills and contracts due to merchants and others.	5,837.84
TOTAL RECEIPTS	$9,517,359.67
TOTAL EXPENDITURES	7,594,226.88
TOTAL CASH ON HAND, May 31, 1909, after deducting outstanding unpaid vouchers, unpaid pay checks, unpaid time vouchers, unpaid demands, unpaid apportionment checks, unpaid bills payable	$1,923,132.79

For detail of expenditures, see the following Schedule:

SCHEDULE OF EXPENDITURES

GENERAL EXPENSE ACCOUNTS

SALARIES OF GENERAL OFFICERS This account represents the salaries of general executive officers and their executive assistants, exclusive of field engineers.	$ 47,770.41
SALARIES OF CLERKS AND ATTENDANTS To this account is charged the salaries of clerks of all kinds, stenographers, copyists, etc., in general offices.	60,035.47
OFFICE SUPPLIES AND EXPENSE This account represents the cost of expense and supplies in the general offices at Los Angeles, and carries such items as rent, personal and traveling expenses, office furniture and fixtures, and all expenses of like nature.	57,388.52
STATIONERY AND PRINTING This account represents the amount spent for printing of reports, annual and monthly, specifications, etc. It also carries the cost of all forms, blank books, stationery and stationery supplies used in the general offices and the field.	13,490.38
LEGAL EXPENSES This account represents the amount spent for salaries and expense of assistant attorneys, law books, briefs, legal forms, notarial fees, cost of suits, and items of a like nature.	28,031.75
INSURANCE This account represents the amount paid for premiums of fire insurance carried.	761.57
TAXES This account represents the amount paid out for taxes on property owned by the city in connection with the water project, in Los Angeles and other counties.	13,330.30

OTHER EXPENSES This account represents the amount paid out for incidental expenses that are not chargeable directly to the above mentioned accounts, the major part of it being incurred through preliminary examinations, investigations, etc., after the inception of the project.	14,201.99
TOTAL GENERAL EXPENSE	$ 235,010.39

AQUEDUCT CONSTRUCTION ACCOUNTS

ENGINEERING This account represents the amount spent for preliminary and final location work of the Aqueduct; also carries Los Angeles Drafting Room expenses.	$ 268,842.28
WATER RIGHTS, REAL ESTATE AND RIGHTS OF WAY This account represents the cost of lands, water rights and rights of way, all for the purpose of Aqueduct construction or for collection of water which will flow into the Aqueduct.	1,595,103.04
GRADING This account represents the amount paid out for excavating for cement lined conduit, whether by teams, dredge or mechanical excavators.	58,172.55
TUNNELS This account represents the amount paid out for the driving of tunnels through which the cement lined conduit will pass.	1,356,893.04
CONDUIT This account represents the cost of cement lined conduit through which the water is carried to Los Angeles.	359,347.99
RESERVOIRS AND HEADWORKS This account represents the cost of reservoirs constructed for the collection and storage of water to feed the cement lined conduit.	18,912.33
CROSSINGS This account represents the cost of crossings over the cement lined conduit.	281.96
TELEGRAPH AND TELEPHONE LINES This account represents the cost of telegraph and telephone lines necessary to carry on the construction of the Aqueduct.	56,650.34
ELECTRIC POWER PLANTS This account represents the cost of power plants erected at various points to supply electrical energy for Aqueduct construction, the power being generated by water pressure.	108,055.67

MISCELLANEOUS STRUCTURES	This account represents the cost of miscellaneous structures used in Aqueduct construction, and consists of stores, warehouses, division offices, mess halls, bunk houses, etc.	224,093.32
ROADS AND TRAILS	This account represents the cost of roads and trails necessary before the actual work of construction could begin.	150,771.06
TRANSMISSION LINES	This account represents the cost of transmission lines transmitting electrical energy to the various points of construction.	142,064.91
OTHER EXPENSES	This account represents items in connection with Aqueduct construction that are not chargeable to the above mentioned Aqueduct construction accounts.	466.40
TOTAL AQUEDUCT CONSTRUCTION ACCOUNTS		$4,339,454.89

EQUIPMENT EXPENSE ACCOUNT

MACHINERY AND TOOLS	This account represents certain machinery and tools that cannot properly be charged to any definite account.	$ 36,241.99
LIVE STOCK	This account represents the cost of horses, mules and burros used in the prosecution of the work.	155,991.07
AUTOMOBILES	This account represents the cost of automobiles used in transporting Chief Engineer and other officials to various points on the project.	9,489.20
MISCELLANEOUS	This account represents the cost of vehicles of all kinds and various small tools, etc., that are known as floating equipment.	198,730.45
WELL DRILLING APPARATUS	This account represents the cost of apparatus used in sinking wells at various points along the Aqueduct for the purpose of determining water supply, also used in water investigation.	1,317.37
TRACTION ENGINES	This account represents the cost of traction engines used for transportation purposes.	20,279.49
STEAM SHOVELS	This account represents the cost of steam and electric shovels used for excavation along the line of the work.	17,233.04

MISCELLANEOUS CAMP EQUIPMENT This account represents the cost of miscellaneous camp equipment that will be moved from time to time as necessity arises.	5,701.15
TOTAL EQUIPMENT EXPENSES	$ 444,983.76

GENERAL LEDGER ACCOUNTS

BILLS COLLECTIBLE This account represents money due from individuals and companies, etc., amounts having been previously expended by the Aqueduct and charged against them.	$ 48,590.32
RAILROAD CONSTRUCTION This account represents amount paid out for railway facilities, such as sidings, etc., both owned and leased by the Aqueduct.	11,708.07
TEAM TRANSPORTATION This account represents the amount paid out for hauling by teams material, supplies, machinery, etc., to points of expenditure.	145,072.12
FREIGHT AND EXPRESS This account represents the amount paid out for railway freight and express on material, supplies, machinery and equipment to nearest point of expenditure.	404,285.33
CEMENT INVESTIGATION This account represents the cost of investigating as to the feasibility and advisability of the city owning its own cement manufacturing plant.	7,556.48
STORE STOCK AND MATERIAL ON HAND ACCOUNTS This account represents the unexpended material and supplies on hand in the various stores and under the care of accountable officers along the line of the Aqueduct.	916,890.35
CEMENT MILL CONSTRUCTION This account represents the charges made against the construction of the city's cement manufacturing plant near Tehachapi, to date.	421,588.63
WATER INVESTIGATION This account represents the cost of investigating as to the sources and supply of water that is to flow into the Aqueduct to the City of Los Angeles.	23,416.04
WATER SUPPLY This account represents the cost of pipe lines, etc., necessary to bring pure, wholesome water from available sources to the line of the Aqueduct for construction purposes and camp use.	184,488.22

WATER DEPARTMENT	16,896.98
This account represents the money advanced for the Water Department of the City of Los Angeles in connection with the operation of ranches in Owens Valley, maintenance of canals, ditches, etc., necessary to hold the water rights, and things of like nature.	
TRACTION ENGINE TRANSPORTATION	5,758.97
This account represents the amount paid out for hauling by traction engine of material, supplies and equipment, etc., to point of expenditure.	
ENGINEERING SUSPENSE	2,552.89
This account represents the cost of special engineering in connection with the testing of machinery, cement, etc., all preparatory to installation; also various schemes for reducing the cost of construction, etc.	
SUSPENSE ACCOUNT	283,960.06
This account represents money that has been expended for various purposes, that at this time cannot be charged against any of the above mentioned accounts. It is made up of a multitude of small accounts, held in abeyance to determine to just what account they are to be applied.	
TOTAL GENERAL LEDGER ACCOUNTS	$2,472,764.46

OPERATING AND MAINTENANCE ACCOUNTS

HYDRO-ELECTRIC POWER PLANTS	$ 5,338.29
This account represents the cost of operating and maintaining hydro-electric power plants, and includes such items as salaries, supplies, etc.	
POWER LINES	6,207.77
This account represents the cost of maintaining power lines. It includes the wages of patrolmen, line riders, etc.	
TELEPHONE LINES	6,190.50
This account represents the cost of operating and maintaining telephone lines and service. Includes the cost of operators, patrolmen, line riders, etc.	
WATER SUPPLIES	7,899.04
This account represents the cost of maintaining pipe lines, springs, water hose, etc. Includes the wages of pipe men and all others engaged in work of this nature.	
ROADS AND TRAILS	3,874.22
This account represents the cost of maintaining roads that have been built; including bridges in connection therewith.	
RED ROCK RAILWAY	3,550.83
This account represents the cost of operating an eight mile railroad running from a point near Cantil. This road is used for the transportation of material, supplies	

and equipment through the Red Rock Canyon to Red Rock Summit, the terminus being Dove Springs.	
CEMENT PLANT **This account represents the cost of operating Cement Plant from March 15, 1909.**	55,811.25
POWER PURCHASED **This account represents the cost of power furnished by the Edison Electric Company, same being used in the prosecution of the work in Division 11, and Elizabeth Tunnel.**	12,955.99
OTHER EXPENSES **This account represents various small items that cannot be applied at this time to any of the above accounts, but will be adjusted later.**	185.49
TOTAL OPERATING AND MAINTENANCE ACCOUNTS	$ 102,013.38
TOTAL EXPENDITURES	7,594,226.88

ITEMS OF GENERAL INTEREST

Pay Rolls

This exhibit shows the amount paid out for salaries and labor in monthly progression from June, 1907, that being the date actual construction was begun:

1907	—June	$ 9,561.59
	July	11,005.31
	August	12,088.33
	September	14,516.37
	October	16,790.24
	November	21,402.55
	December	22,726.96
1908	—January	26,682.30
	February	29,019.09
	March	40,446.52
	April	46,054.27
	May	50,308.32
	June	54,058.64
	July	60,436.31
	August	68,820.27
	September	84,069.83
	October	131,021.10
	November	168,100.21
	December	187,658.72
1909	—January	222,745.02
	February	219,746.97
	March	273,060.07
	April	290,221.40
	May	310,304.60

Pay Rolls

This exhibit shows the actual number of men appearing on the pay rolls in monthly progression from November 30, 1908, to May 31, 1909:

December, 1908	3879
January, 1909	4150
February	4492
March	5304
April	5250
May	6060

Correct:

E. V. HARDING,
Accountant.

W. M. NELSON,
DISBURSING AGENT
AND CHIEF ACCOUNTING OFFICER

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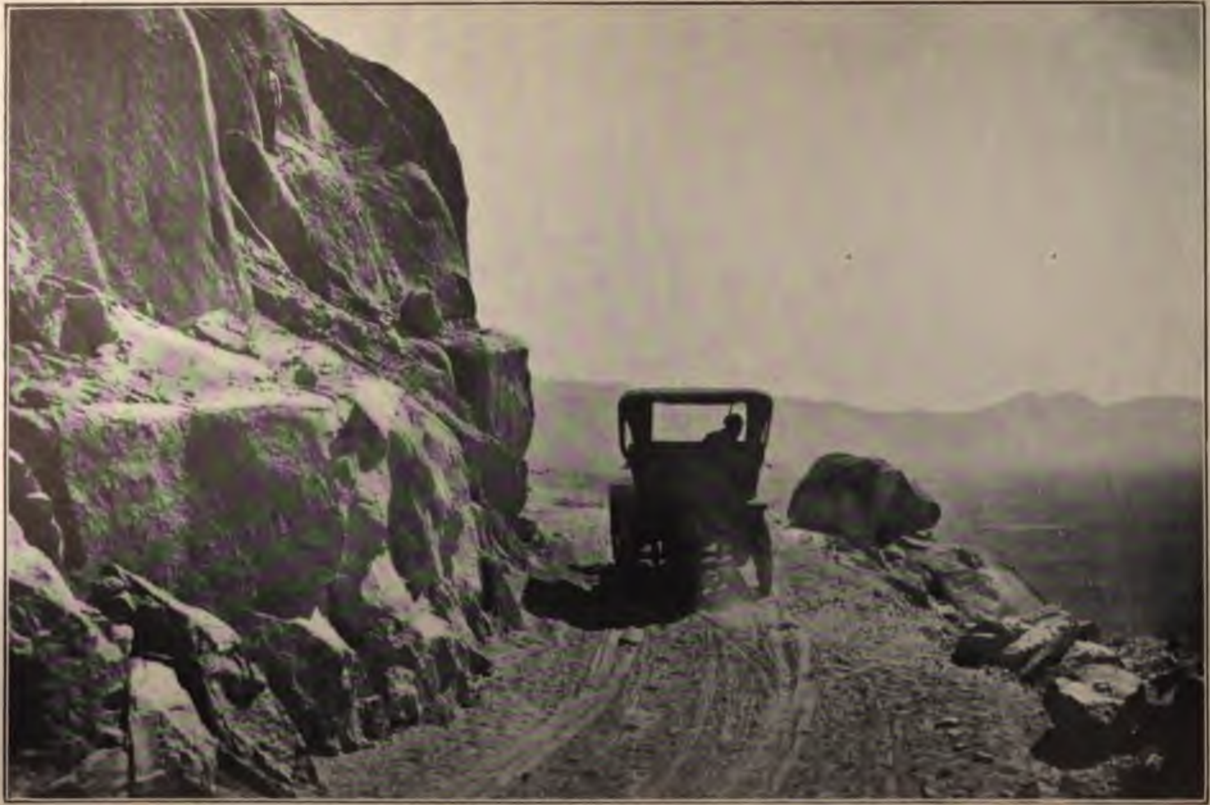


ROAD IN BOULDER PEAK SECTION, GRAPEVINE DIVISION

Report of the Legal Department

LOS ANGELES AQUEDUCT

June 30, 1909.

To the Honorable Board of Public Works
of the City of Los Angeles.

Gentlemen: I beg to submit the following report of work done by the Legal Department of the Aqueduct Bureau since my last report, to-wit: November 30, 1908.

Very respectfully,
W. B. MATHEWS.

CONTRACTS

The following is a complete list of the contracts prepared by the Legal Department of the Bureau of the Los Angeles Aqueduct, for machinery, equipment, materials, supplies and services, since the date of the last Annual Report, November 30, 1908, including contracts founded on specifications approved by the Board of Public Works and awards made after advertisement, and contracts made without advertisement, under the emergency provisions of the City Charter:

A. CONTRACTS MADE AFTER ADVERTISEMENT FOR BIDS

Spec. No.	Contractor	Date	Subject	Amount
45	Westinghouse Elec. & Mfg. Co.	11-30-08	Locomotives, Generator Sets and Motors	$31,000.00
49	United Iron Works	12-17-08	Pumps and Check Valves	2,178.00
49	Byron Jackson Iron Works	12- 7-08	Joints and Pumps	1,480.00
46	P. A. Howard	12-12-08	Construction work on Antelope Division of the Aqueduct — Lining tunnel, $12.00 lin. ft. Completed and lined tunnel, $30.00 lin. ft. Canal lining with cover, $6.20 per lin. ft. Excavating, 40c per cu. yd. Plain and rubble concrete, $8.00 per cu. yd.	

Spec. No.	Contractor	Date	Subject	Amount
	P. A. Howard	12-31-08	Modifying above contract.	
51	J. A. Hill	12-31-08	Transportation of freight —28c and 30c per ton mile.	
52	Union Oil Co. of Cal., and Associated Oil Co.	12-30-08	Fuel oil—75c per bbl.	
	Union Oil Co. of Cal., and Associated Oil Co.	6- 7-09	Modifying above contract.	
47	Abner Doble Co	1- 2-09	Water Wheel	$ 4,500.00
47	Westinghouse Elec. & Mfg. Co	2- 4-09	Electrical Apparatus	18,800.00
47	Allis-Chalmers Co	1- 9-09	One Exciter Unit	1,841.00
55	E. K. Wood Lumber Co.	1-30-09	Lumber—From $10.50 to $40.00 per M ft.	
57	Marion Steam Shovel Co.	3-19-09	Four Steam Shovels	26,800.00
58	Holt Mfg. Co	3-26-09	Traction Engines and Wagons	133,870.00
59	E. P. Bosbyshell Co	4- 5-09	Wagons	434.10
59	Hawley, King & Co	4- 5-09	Wagons and Wagon Gears	4,935.50
60	Lacy Mfg. Co	4- 8-09	Hull for Dredge	1,060.00
60	Fulton Engine Works	4- 9-09	Derrick for Dredge	850.00
61	Los Angeles Saddlery & Finding Co	4-14-09	Harness	3,713.70
62	Union Hardware & Metal Co	5- 4-09	Twisted Steel Bars — From $1.29½ to $1.59½ per 100 lbs.	
62	American Steel & Wire Co	5- 7-09	Wire Fabric—50c per 100 sq. ft.	
65	Marion Steam Shovel Co.	5- 7-09	Steam Shovel Teeth and Points	1,000.00
67	Pacific Coast Mfg. Co	5-11-09	Drilling Equipment	12,150.00
67	Fairbanks-Morse & Co	5-11-09	Air Drills	900.00
69	Corrugated Bar Co	6- 1-09	Twisted Steel Bars — $1.24 per 100 lbs.	
69	American Steel & Wire Co	5-19-09	Wire Fabric—50c per 100 sq. ft.	
70	Kelman Electric & Mfg. Co	5-24-09	Oil Switch	355.00
66	Arthur Koppel Co	6-11-09	Dump Cars	2,364.00
72	Ralph C. Hamlin	6- 2-09	Automobile	3,955.00
71	Llewellyn Iron Works	6-11-09	Mining Cars, Gears and Bodies	1,571.50
73	General Electric Co	6-10-09	Motors	2,417.60
74	Union Hardware & Metal Co	6-29-09	Shovels	2,850.65
70-B	Baker Iron Works	12- 3-08	Tunnel Cars	2,450.00
85-B	Jordan Oil Co	11-25-08	Engine Distillate—8c per gal.	
91-B	San Pedro Lumber Co	12- 1-08	Lumber, Doors, Windows and Screens	1,257.46
90-B	Union Hardware & Metal Co	12- 5-08	Black Blasting Powder— $1.40 per keg.	
88-B	W. L. Cleveland Co.	12- 9-08	60 H. P. Engine	1,700.00
95-B	Wm. H. Hoegee Co.	12- 4-08	Tents and Flies	887.50
74-B	Municipal Engineering & Contracting Co.	12-10-08	Concrete Mixers	1,918.00

Spec. No.	Contractor	Date	Subject	Amount
74-B	Fairbanks, Morse & Co.	12-13-08	Concrete Mixers	$ 2,610.00
94-B	Standard Underground Cable Co.	12-23-08	Electric Cable—From 10.1c to 54.5c per ft.	
104-B	E. K. Wood Lumber Co.	12-17-08	Lumber, Doors, Windows and Screens	690.07
105-B	C. W. Dunning	12-14-08	Concrete Mixers	1,770.00
99-B	Llewellyn Iron Wks.	1- 7-09	Tunnel Cars	8,300.00
102-B	Harper & Reynolds Co.	12-23-08	Rails, Splice Bars and Spikes—Rails: $26.45 and $28.45 ton. Splice Bars: 12c and 18c per pair. Spikes: $2.25 per cwt.	
103-B	Baker Iron Wks.	12-28-08	Riveted Steel Pipe	5,260.00
100-B	Fairbanks, Morse & Co.	12-29-08	Endless Leather Belts—$2.33 per ft.	
98-B	Pacific Coast Mfg. Co.	1- 6-09	Steam Hammer	1,115.00
92-B	Pacific Coast Mfg. Co.	1-13-09	Triplex Pumps	1,665.00
92-B	Fulton Engine Wks.	1- 8-09	Triplex Pump	995.00
106-B	H. R. Boynton Co.	1- 8-09	3½" Casing—$15.59 per 100 ft.	
58-B	Union Hardware & Metal Co., California Hardware Co., and Harper & Reynolds Co.	1-11-09	Dynamite, Fuse and Caps—Dynamite: From 10¼c to 13¾c per lb. Fuse: $21.00 per case. Caps: $6.50 per M.	
103-B	Llewellyn Iron Wks.	1-11-09	Self-contained Hoist	1,248.00
109-B	Newmark Grain Co.	1- 9-09	Rolled Barley—$30.50 per ton.	
97-B	Smith - Booth - Usher Co.	1-29-09	Lathes and Drill Presses	1,460.00
97-B	Pacific Coast Mfg. Co.	1-26-09	Emery Grinders, Band and Hack Saws	782.30
110-B	Pacific Coast Mfg. Co.	1-18-09	6" Casing—$31.20 per 100 ft.	
111-B	Crane Co.	1-20-09	2" Black Iron Pipe—$8.11 per 100 ft.	
111-B	Harper & Reynolds Co.	1-18-09	Pipe Fittings	9.10
112-B	Llewellyn Iron Wks.	1-28-09	Tunnel Forms	1,400.00
113-B	Mellus Bros. & Co.	1-28-09	Tents and Flies	906.25
116-B	California Hardware Co.	2- 5-09	1" Black Iron Pipe—3.85c per ft.	
116-B	Pacific Coast Mfg. Co.	2- 8-09	2" Black Iron Pipe—$8.42 per 100 ft.	
126-B	C. Leonardt	2-15-09	Twisted Steel Bars—$2.20 per 100 lbs.	

Spec. No.	Contractor	Date	Subject	Amount
126-B	American Steel & Wire Co.	2-10-09	Steel Wire Fabric—$0.74 per 100 sq. ft.	
114-B	Standard Oil Co.	2-13-09	Engine Distillate—8c per gal.	
118-B	Standard Oil Co.	2-13-09	Mining Candles	$ 4,400.00
115-B	Fulton Engine Wks.	2-25-09	Cable Reels	580.00
117-B	R. H. Herron Co.	2-23-09	Iron Pipe—Approximately	10,544.94
120-B	California Cornice Wks.	2-23-09	Corrugated Iron	507.52
121-B	B. F. Kierulff, Jr., & Co.	2-25-09	Cedar Poles—$4.25 each.	
121-B	Chas. Wier & Co.	2-25-09	Cedar Poles—$4.25 each.	
123-B	Fairbanks, Morse & Co.	2-26-09	Concrete Carts	975.00
127-B	Smith - Booth - Usher Co.	2-27-09	Cycloidal Blowers	1,416.00
124-B	Hawley, King & Co.	3- 4-09	Wagons	1,576.00
124-B	Newell Mathews Co.	3- 4-09	Wagons	1,774.50
134-B	California Portland Cement Co.	3- 2-09	Cement—$1.90 per bbl.	
132-B	California Hardware Co., Harper & Reynolds Co., and Union Hardware & Metal Co.	3- 4-09	Explosives—Approximately	65,633.33
122-B	Crane Co.	3-11-09	Pipe Fittings	1,047.64
130-B	Wm. H. Hoegee Co.	3-13-09	Tents and Flies	4,437.50
128-B	Union Hardware & Metal Co.	3-12-09	"T" and Angle Iron—$1.49 and $1.64 per 100 lbs.	
119-B	Pierson, Roeding & Co.	3-15-09	Rail Bonds and Rail Bond Compressor	835.40
138-B	Newmark Grain Co.	3-12-09	Rolled Barley	5,980.00
136-B	Baker Iron Wks.	3-12-09	Riveted Pipe	2,340.00
137-B	Arthur Koppel Co.	3-17-09	Rails, Splice Bars, Bolts and Nuts—$41.95 per ton of Rails. 18c per set for Bars, Bolts and Nuts.	
129-B	Wallace - Lindesmith Hoist Co.	3-26-09	Concrete Mixers	850.00
125-B	Smith - Booth - Usher Co.	3-30-09	Concrete Mixers	5,531.00
143-B	Baker Iron Wks.	3-24-09	18" Pipe	1,195.00
139-B	Westinghouse Elec. & Mfg. Co.	3-26-09	Transformers	3,060.00
142-B	Baker & Hamilton	3-31-09	Scrapers	570.00
140-B	Standard Underground Cable Co.	4-21-09	Wire—Approximately	12,155.98
140-B	B. F. Kierulff, Jr., & Co.	4-13-09	Wire	253.00
141-B	L. W. Blinn Lumber Co.	4- 9-09	Cross Arms	483.50
135-B	Pacific Elec. Wks.	4-12-09	Copper Wire—14¼c per lb.	
135-B	John A. Roebling's Sons Co.	4-13-09	Copper Wire—14¼c per lb.	

Spec. No.	Contractor	Date	Subject	Amount
131-B	Pacific Coast Mfg. Co.	4- 8-09	1" and 2" Screw Pipe—$3.04 for 1" and $6.60 for 2" per 100 ft.	
131-B	Crane Co.	4- 8-09	3½" Casing—$13.94 per 100 ft.	
144-B	Crane Co.	4- 8-09	Casing—$13.94 per 100 ft.	
148-B	John A. Roebling's Sons Co.	4- 7-09	Nails	$ 2,002.50
150-B	E. P. Bosbyshell Co.	4-14-09	Dump Carts	615.00
151-B	Baker Iron Wks.	4-13-09	Riveted Pipe	6,367.00
153-B	Crane Co.	4-12-09	6" Casing	2,052.00
147-B	Pierson, Roeding Co.	4-16-09	Trolley Material	792.60
147-B	Holabird, Reynolds Elec. Co.	4-22-09	Elec. Light Materials	1,252.29
147-B	B. F. Kierulff, Jr., & Co.	4-20-09	Incandescent Lamps	1,002.75
145-B	California Elec. Co.	4-18-09	Motors	1,413.90
146-B	Westinghouse Elec. & Mfg. Co.	4-21-09	Meters	1,338.28
155-B	Lacy Mfg. Co.	4-17-09	Water Tanks	540.00
151-B	Baker Iron Wks.	4-20-09	Riveted Pipe	4,648.00
156-B	M. A. Newmark & Co.	4-22-09	Mining Candles	8,600.00
154-B	Los Angeles Blue Print Co.	4-27-09	Transits and Levels	1,905.12
152-B	Pacific Coast Mfg. Co.	4-26-09	Rails and Splice Bars—$22.45 per ton of Rails. $216.50 for the Splice Bars.	
152-B	California Hardware Co.	4-26-09	Rails and Splice Bars—$25.72 per ton of Rails. $324.00 for the Splice Bars.	
149-B—	John A. Roebling's Sons Co.	5- 5-09	Telephone Wire—$3.80 per 100 lbs.	
157-B	Crane Co.	5-14-09	1" Pipe—$3.14 per 100 ft.	
159-B	Consolidated Pipe Co.	5-11-09	Casing, Starters and Shoes—Casing: $1.64 per ft. Starters: $1.92 per ft. Shoes: $16.25 each.	
160-B	Wm. H. Hoegee Co.	5-10-09	Tents and Flies	4,406.25
161-B	San Pedro Lumber Co.	5-10-09	Lumber	2,313.00
163-B	Newmark Grain Co.	5-19-09	Rolled Barley—$32.75 per ton.	
165-B	San Pedro Lumber Co.	5-20-09	Lumber	567.47
164-B	Wm. H. Hoegee Co.	5-20-09	Army Cots	1,775.00
166-B	Philip Friedman	5-21-09	Steel Ribs	1,300.00
167-B	Nicholls-Hammell-Loomis Co.	5-26-09	Barley Hay	2,500.00
162-B	Acme Cement Plaster Co.	6- 1-09	Gypsum	250.00
158-B	Pacific Coast Mfg. Co.	6- 7-09	Rails and Fish Plates—Rails: $23.45 per ton. Fish Plates: 14½c per pair.	

Spec. No.	Contractor	Date	Subject	Amount
158-B	Harper & Reynolds Co.	6- 9-09	Rails and Fish Plates—Rails: $23.39 per ton. Fish Plates: 20¾c per pair.	
168-B	Baker Iron Wks.	6-11-09	Steel Ribs	$ 389.00
170-B	Lacy Mfg. Co.	6-17-09	Riveted Pipe	840.00
176-B	Newmark Grain Co.	6-30-09	Rolled Barley	7,500.00

B. CONTRACTS MADE WITHOUT ADVERTISEMENT FOR BIDS

Contractor	Date	Subject	Amount
Geo. W. Stimson and Chas. M. Stimson	12- 1-08	Water for Domestic and Construction Work—30c per 1000 gal.	
Nettleton and Kellerman Oil Co.	12-31-08	Water for Domestic and Construction Work—$40.00 per annum.	
California Portland Cement Co.	1-22-09	Cement—$1.50 per bbl.	
Kern River Co.	2-11-09	Material for Power Line.	$ 123.61
Arthur Weldon	2-15-09	Water for Domestic and Construction Work—$100.00 per annum.	
Salome B. de Raggio, et al.	3-31-09	Gravel and Right of Dumping	250.00
Marion Steam Shovel Co.	4-13-09	Electric Shovels	19,850.00
Truxton Beale, Trustee	4-22-09	Water for Domestic and Construction Work	1,000.00
Robert Sherer & Co.	5- 5-09	Rails—$35.00 per ton.	
Pacific Coast Mfg. Co.	5- 7-09	Leyner Drills and Repair Parts	5,978.77
Thos. Prosser & Son	5-19-09	Ball and Tube Mill	6,070.00
O. F. Goodrich	6- 1-09	Telephone Service—$10.00 per month.	
La Costa Land & Town Co. and Thomas E. Metcalf	6- 2-09	Pebbles—$2.00 per ton.	
Marion Steam Shovel Co.	6-18-09	Machinery for Electric Dredge	8,000.00
Marion Steam Shovel Co.	6-21-09	Repair Parts for Power Shovels	5,286.22
Southern Pacific Co.	6-21-09	Spur at Saugus—Not exceeding $750.	

LANDS AND RIGHTS OF WAY

The following is a complete list of purchases of lands and rights of way for the Aqueduct system, since the date of the last Annual Report, November 30, 1908:

A. LANDS

Name of Seller	Acreage
Brown, A. R.	400
Carpenter, George	80
Connor, James	320
Currie, A. N.	160
Dell, Andrew	360
Dooley, Georgia J.	160

Name of Seller	Acreage
Duhart, Juan	6.20
Gerken, Henry	320
Gunn, Eva L.	1.3
Mathieu, Auguste	160
McCullough, G. N	240
Murphey, Thomas J	160
Naylor, George W	160
Owens River Land & Cattle Company	2865
Owens River Land & Cattle Company	200
Partridge, Cecilia C	160
Partridge, Charles A	80
Raggio, Salome B. de, et al (Easement)	00
Rose, C. N	160
Sanders, B. H	400
Sanders, C. V	160
Sanders, Elias W	200
Sanders, J. F	320
Schober, Edward	640
Scott, Clara A	80
Seymoure, Sidney	160
Sierra Securities Company (exchanged for 146.7 acres)	215.89
Smith, Walter & Mary E	128.71
Snyder, Ferdinand Sr. and Ferdinand Jr. (Easement)	80
Summit Lime Company	9.32
Tharin, Charles E	20
Watterson, M. Q	240
Wells, A. L	160
United States of America	627.78
Vaughan, W. C	80

B. RIGHTS OF WAY OVER PRIVATE LANDS

Bank of Tehachapi	.15
Beale, Truxton	.00
Davis, Hibbard O. (Exchange)	.00
Duarte, Antonio	.00
Green, Wilber F. (Relinquishment to U. S. A.)	4.87
Hoffmann, Jacob and Marie Antoinette	1
Hoffmann, Jacob and Marie Antoinette	.00
Kern River Company	.00
McCarty, Eugene C	4.17
Monroe, Mary Eliza	1.03
Monroe, Mary Eliza	.00
Mortimer, C. White	.80
Perry, Alice	1.82
Reynolds, C. M	.00
Ruby, Amanda	2.20
Shepherd, M. W	.00
Standard Oil Company	9.8
Spratt, Jimmie	3.77
Walk, Albert B. (Exchange)	1.65

Name of Seller	Acreage
Watson, David (Exchange)	275
Watson, Arthur	80
Wilson, W. [illegible]	32

LANDS AND RIGHTS OF WAY SECURED FROM THE UNITED STATES UNDER THE ACT OF JUNE 30, 1906

Aqueduct line in Independence Land District.

Amendments to Aqueduct line in Independence Land District.

Amendments to Aqueduct line in Los Angeles Land District.

Division Creek Ditch pipe line power station site and transmission line in Independence Land District.

Division Creek pipe line and power station site No. 2 in Independence Land District.

Cottonwood Creek ditch pipe line and power station site in the Independence Land District.

Haiwee Creek pipe line in Independence Land District.

Amendment to Fairmont Reservoir site in Los Angeles Land District.

SPECIAL USE PERMITS ISSUED BY THE FOREST SERVICE OF THE UNITED STATES

Location	Purpose
Owens Valley	Pasture
San Francisquito Canyon	Construction Camp

PROCEEDINGS IN THE DEPARTMENTS AT WASHINGTON, D. C., IN WHICH APPEARANCE HAS BEEN MADE IN BEHALF OF THE CITY FOR THE PURPOSES OF A CONTEST, ADJUSTMENT, OR OTHERWISE

Contest with George Chaffey in re his application for reservoir sites on Cottonwood Creek.

Contest with George Chaffey in re his application for rights of way on Cottonwood Creek.

Contest with George Chaffey in re his application for rights of way on Oak Creek.

Contest with George Chaffey in re his application for rights of way on Shepherd's Creek.

Contest with George Chaffey in re his application for rights of way on Independence Creek.

Contest with George Chaffey in re his application for rights of way on George's Creek.

Contest with the Silver Lake Power & Irrigation Company in re its application for reservoir site in Long Valley, Mono County. In this matter the Department sustained the city's protest and denied such application.

Contest with the Silver Lake Power & Irrigation Company in re its application for rights of way on Owens River. The Department sustained the city's protest and denied such application.

Contest with the Round Valley Water Users Association in re its application for rights of way on Rock Creek.

Contest with F. R. Smith in re his application for rights of way on Rock Creek.

Contest with the Owens River Water & Power Company in re its application for rights of way on Owens River.

Contest with the Mono Power Company in re its application for rights of way on Owens River.

Contest with Grant and Arnot in re their application for rights of way on Cottonwood Creek.

Contest with J. M. Taylor in re his application for rights of way on Owens River.

SUITS AFFECTING THE AQUEDUCT

The City of Los Angeles vs. Daniel Curtis, et al. Superior Court Los Angeles County. To condemn rights of way. Compromised and dismissal about to be entered.

John F. Dixon vs. Fred Eaton, et al. Superior Court Inyo County. To condemn rights of way. On demurrer.

Inyo Consolidated Water Company vs. Stoddard Jess, et al. Superior Court Inyo County. To quiet title to waters of Cottonwood Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Lone Pine Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Oak Creek. On demurrer.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Independence Creek. On demurrer.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Shepherd's Creek. On demurrer to second amended complaint.

Inyo Consolidated Water Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of George's Creek. On demurrer to second amended complaint.

City of Los Angeles vs. Jameson Lime Company, et al. Superior Court Kern County. To condemn rights of way. On demurrer.

City of Los Angeles vs. Bridget McGann, et al. Superior Court Inyo County. To condemn rights of way. Compromised and will be dismissed.

Owens River Land & Cattle Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to lands. On demurrer.

Silver Lake Power & Irrigation Company vs. City of Los Angeles. Superior Court Mono County. To quiet title to waters of Owens River and other streams. Amended complaint filed and served.

Silver Lake Power & Irrigation Company vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Owens River. On demurrer to amended complaint.

A. St. Clair Perry vs. City of Los Angeles, et al. Supreme Court State of California. On appeal.

E. R. Fox vs. A. A. Hubbard, et al. Supreme Court State of California. On appeal.

C. Howard Merritt vs. City of Los Angeles. Superior Court Inyo County. To quiet title to waters of Haiwee Creek. Set for trial.

City of Los Angeles vs. Owens River Canal Company. Superior Court Inyo County. To enjoin diversion waters of Owens River. Order to show cause issued.

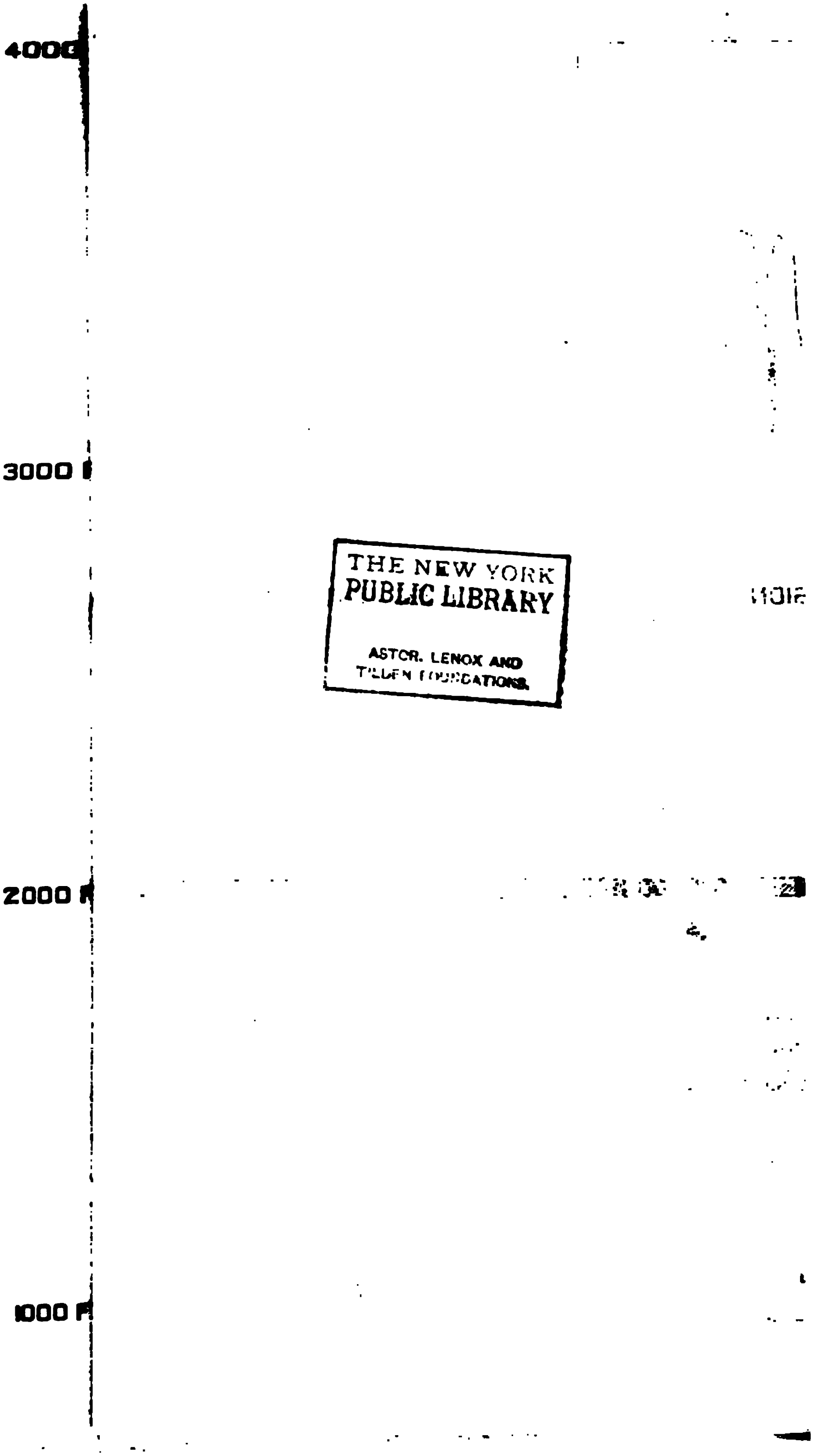
CITY OF LOS ANGELES

FIFTH ANNUAL REPORT

OF THE BUREAU OF THE

LOS ANGELES AQUEDUCT

JULY 1, 1910



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CITY OF LOS ANGELES
Department of Public Works

FIFTH ANNUAL REPORT

of the Bureau of the

LOS ANGELES AQUEDUCT

THE BOARD OF PUBLIC WORKS

BOARD OF PUBLIC WORKS

ALBERT A. HUBBARD, President
LIEUT.-GEN'L ADNA R. CHAFFEE
W. M. HUMPHREYS

LOS ANGELES, CALIFORNIA
1910

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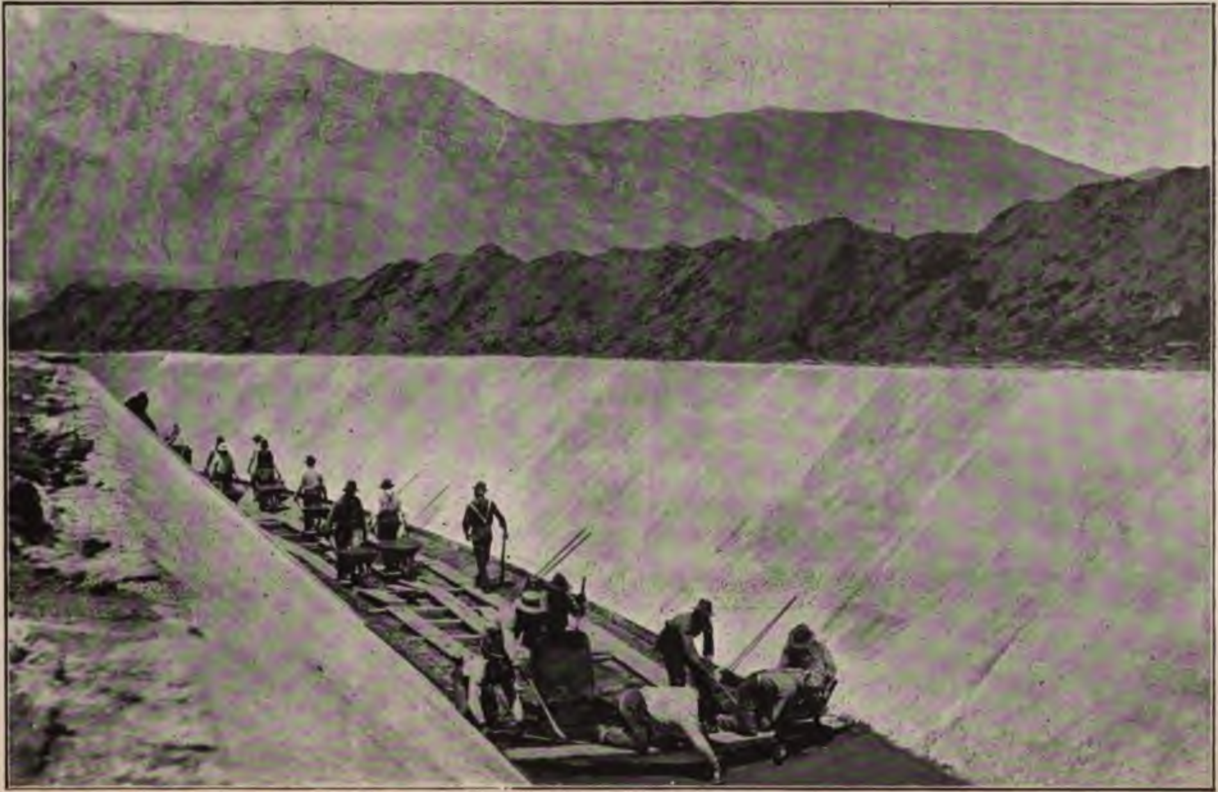

PUTTING THE BOTTOM IN THE CONDUIT, OLANCHA DIVISION—300 FEET A DAY.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

BOARD OF PUBLIC WORKS OF THE CITY OF LOS ANGELES

BUREAU OF THE LOS ANGELES AQUEDUCT

WM. MULHOLLAND, *Chief Engineer*
J. B. LIPPINCOTT, *Asst. Chief Engineer*

Los Angeles, Cal., July 18, 1910.

The Honorable Board of Public Works.
City of Los Angeles.

Gentlemen: Herewith is presented the annual report of the Los Angeles Aqueduct for the fiscal year ending July 1, 1910. The subject is so fully treated in the report that special comment is here unnecessary.

Up to the time of the interruption of the work a month or two ago, by reason of lack of funds, the program set out in the last annual report was being everywhere realized, and in some instances surpassed, notwithstanding the fact that last winter was an unusually severe one on the desert, there being unprecedented periods of extremely cold weather which interfered with the building of concrete structures. There were some instances where concrete was so injured by frost as to require its removal. This condition, which involved the cessation of work, resulted in a temporary disorganization of our forces and a delay afterwards in reassembling them.

It is impossible to suspend work, even for a short period, on the desert and retain the crews, as men will not stay in unattractive camps when they are not on an earning basis. The recent suspension of work well illustrates this. The dispersal of our forces has resulted not alone in making the men we had, unavailable at once, but the broadcast announcement that the Aqueduct work was suspended, deterred the usual drift of labor from abroad. It looks now as though the upbuilding of the force to its usual complement will be a work of months. Our severest loss is due to the scattering of the many competent and well-trained foremen, to whose energy and trained intelligence much of our great progress in the past has been due.

Had we been able to keep up the progress that was attained during the months of March, April and May, 1910, there would be no possible chance for doubt of our ability to complete the Aqueduct by the spring of 1912. There is a bare possibility that this may yet be done, but it will depend largely upon the promptness with which the recent calamity of the disorganization of our forces may be amended.

The present year being one of extreme drouth in the Sierra Nevada, gives us opportunity in our hydrological studies to fully gage the sufficiency of the water supply in the Owens Valley. The observations so far in that respect are confirmatory of our past confidence in the deductions of the early published studies of this subject.

As all the difficult work on the Aqueduct is, at the present time, nearly completed, the possibility of any contingency intervening to prevent the finishing of the Aqueduct within the estimates is remote.

Thanking the Board in behalf of myself and colleagues for its kindly assistance and approbation of our efforts, I remain,

Very respectfully,

WM. MULHOLLAND,
Chief Engineer.

REPORT OF THE ENGINEERING DEPARTMENT FOR THE FISCAL YEAR ENDING JUNE 30, 1910.

Owens Valley Division (No. 2)

As has been mentioned in former reports, conduit work on this division is confined to the operation of dredges, on account of the proximity of the water plane to the natural surface. Dredges No. 1 and 2, equipped with heavy centrifugal pumps, have worked steadily throughout the year, accomplishing a total of 15,200 and 19,595 feet respectively. A deposit of travertine having been found to underlie a portion of the uncompleted canal in such quantity as to render its removal by such dredges impossible, a dipper dredge was purchased and placed in commission in January. This dredge is practically a Model 60 Marion power shovel mounted on a scow instead of running gear, and it is intended on the completion of this division, to supply the necessary trucks and place the shovel in the heavy work which will be encountered in the Alabama Hills.

This dredge has completed 20,892 feet of canal since its installation, making a total of 62,400 feet completed on the whole division. It is estimated that the dipper dredge can alone complete all remaining footage on this division in one year, and it is therefore planned to dismantle one suction dredge and use the equipment elsewhere, leaving Dredge No. 2 for maintenance operation in the future.

Labor conditions have been good in this section, and the weather has been uniformly suitable for work with the exception of the months of December and January, which were extremely cold.

Mr. H. A. Van Norman is division engineer on this work.

Olancha Division (No. 3)

The Nevada and California Railroad having been extended to Olancha during the fall of 1909, the organization of this division was perfected under the direction of O. W. Peterson, division engineer. Two Model 60 Marion steam shovels and one electric shovel of similar type were purchased and installed at points averaging four miles apart. The conduit at this point is of 900 second feet capacity, and the theoretical section is 35 feet across the top, rendering it necessary to equip these shovels with extra long booms in order to place the spoil beyond the edge of the excavation. The material encountered is of the ordinary desert soil, mixed with boulders of varying size, some requiring the use of Giant Powder for their removal.

Concrete materials are found adjacent to the location in great variety, and are delivered to the mixers at a cost of less than $1.00 per cubic yard. No forms are used in lining this style of conduit, as may be noted in the photographs. The side slope being one horizontal to one vertical, the concrete is laid like a pavement in alternate sections, expansion joints being left at 12 foot intervals.

The following table shows the progress of each shovel up to date:

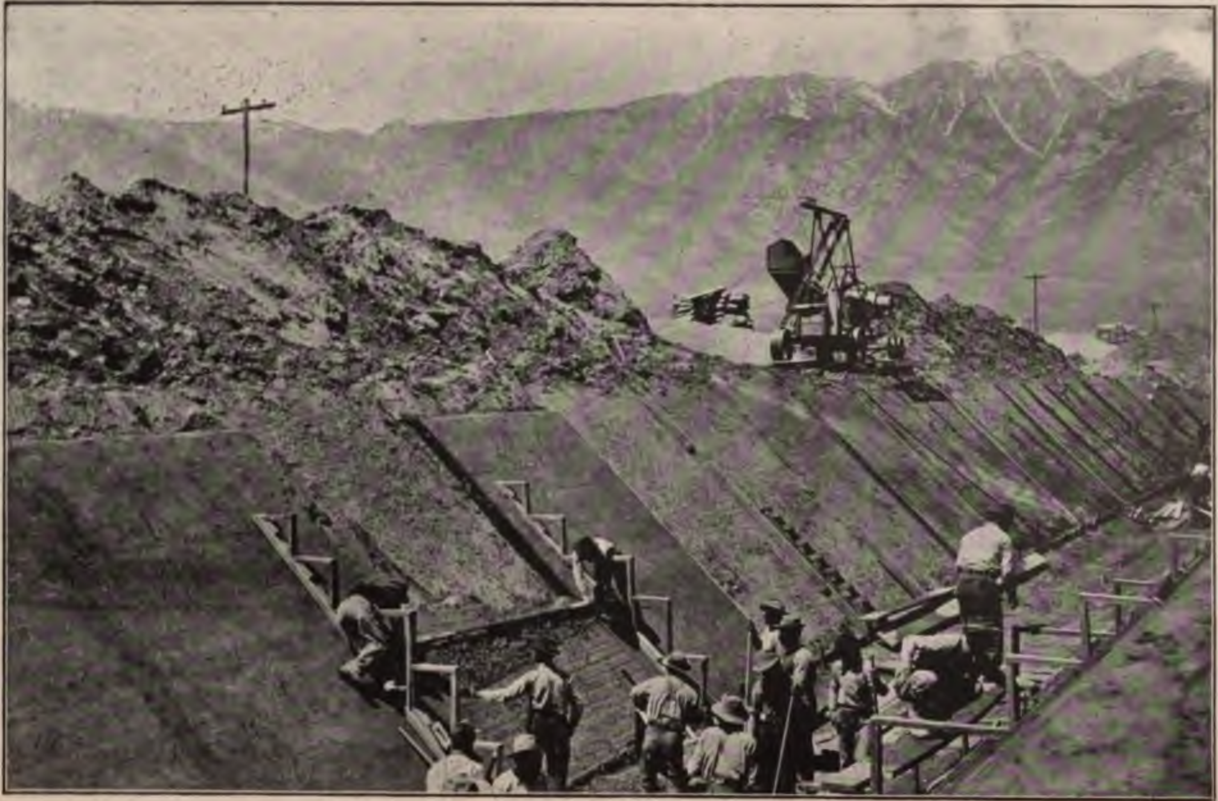
Shovel No. 9	8,613 ft.	Installed February, 1909.
Shovel No. 10	5,645 ft.	Installed March, 1909.
Shovel No. 11	1,754 ft.	Installed May, 1909.

Labor conditions have been fairly good during the year, a certain supply having been obtained from the shipments of men made by the railroad contractors. No especially rigorous climatic conditions have been encountered. It is expected that the division will be entirely completed during the coming year, allowing the transfer of equipment to the Alabama Hills.

Haiwee Division (No. 3-A)

Work on this division includes all operations necessary for the construction of the upper and lower Haiwee dams, and the operation of an auxiliary plant for the manufacture of modified cement by the addition of certain amounts of ground tufa or volcanic ash. Construction on the dams has been limited to the south Haiwee site, and has been mainly confined to experimental and exploration work. It was originally intended to use only a comparatively shallow puddle wall to restrict seepage, and a trench was accordingly dug by an electric shovel between abutments. Subsequent explorations, however, having shown conclusively that this would be insufficient, shafts were sunk on the axis of the dam to determine the depth to bedrock, and arrangements are now being made to construct an impervious concrete curtain to the natural surface, effectually preventing any loss by underflow.

Sufficient water for conducting hydraulic operations has been secured from Hogback and Haiwee Creeks, nearly 8 miles of main pipe line, varying in diameter from 6 to 12 inches, having been laid. Adequate equipment is now in place and only awaits the completion of the core wall to be placed in active service.



CONCRETING THE SIDES OF THE CONDUIT, OLANCHA DIVISION.

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The tufa plant at Haiwee is the second of this type to be installed on the Aqueduct work, and is situated on the line of the Nevada and California Railroad, in order to command proper shipping facilities. The quarry is about three-quarters of a mile from the mill buildings and the rock is conveyed therefrom by means of a trolley line and electric locomotive. The equipment consists of one Gates ball mill and one Krupp tube mill, driven by electric motors of 75 and 100 horsepower respectively. Excellent results have been obtained with this installation, both as to quantity and quality, and the product is used exclusively for concrete work on the Olancha Division.

Rose Valley Division (No. 4)

No active construction has been done in this section up to date, both on account of the character of the country and because it had been planned to utilize equipment from other portions of the work when the same could be spared.

Preliminary work, including the building of a warehouse and the laying of a pipe line from Talus Creek to the located line, was carried on during the months of March and April under the direction of John Stearns, construction superintendent. Several small fills, with the necessary culverts, were completed and will be allowed to stand and thoroughly settle before the conduit is built across them. As this division is but 13 miles in length, it is estimated that two shovels can complete it within one year.

Little Lake and Grapevine Divisions (Nos. 5 and 5-A)

Geographically, this section may be considered as one division, although it has been divided, for convenience in construction operations, into two parts. This region is of great topographic severity, tunnel following tunnel for mile after mile. Frequently, on the steeper and more threatening slopes, the located line does not emerge at all, but is reached for construction purposes by side drifts or adits, through which the excavated material is conveyed. The materials for construction are transported up the mountain sides by means of aerial and surface trams, and in these districts the engineering work is bold and imposing. Where the conduit work proper is of sufficient extent, a steam shovel is employed for excavation purposes. By means of proper apparatus, the shovel is made to pull itself from the foot of the slope to the required elevation. Rock ledges, or outcrops, lying above the line, are quarried and run through crushers, the product being delivered by gravity through chutes to convenient points for concrete work.

Sand is readily available at all points on the slopes, being formed by the disintegration of the peaks above.

Location revision of this section has resulted in the addition of over 15,000 lineal feet of tunnel, such change eliminating 7,634 feet of side hill conduit, some of which was considered to be on insecure ground, together with the projected siphon crossing at Indian Wells Canyon. Following is a table showing excavation progress:

	Completed during year	Total to date.	Per-centage.
LITTLE LAKE DIVISION.			
Tunnel	18,587	21,986	62
Conduit	1,834	1,945	13
GRAPEVINE DIVISION.			
Tunnel	15,011	17,523	59
Conduit	12,387	12,519	43

C. H. Richards is division engineer of the Little Lake Division, and F. J. Mills is division engineer of the Grapevine Division.

Freeman Division (No. 6)

This section consists of approximately 100,000 lineal feet of covered conduit, and 2,985 lineal feet of tunnel. Of the latter, 82 per cent. has been excavated, or 2,357 feet. One steam shovel and two electric shovels, all of the Model 40 Marion type, have been continuously at work on the conduit excavation, completing a total of 65,162 feet or about 65 per cent. Concrete crews attached to each shovel camp, have followed closely behind the excavation, different gangs being assigned to the placing of bottom, sides and cover.

As this division lies some distance from the main line of the Nevada and California Railway, all construction materials with the exception of sand and gravel, have been hauled from Siding No. 6 over ten miles of broad-gage railroad owned and operated by the city to its terminus, Dove Springs, and thence transported to final destination by teams and traction engines. Labor conditions, on account of the semi-isolation, have been unsatisfactory at certain periods, it being necessary to make shipments of men from time to time to relieve the shortage.

Probably the most noticeable construction feature of this division is the reinforced concrete flume over Freeman Wash. This waterway is somewhat noted for destructive floods, and the conduit is carried across on five 50 foot spans resting on reinforced concrete piers, carried below the surface to safe foundations.

Mr. Louis F. Mesmer has been in executive charge of this division.

Jawbone Division (No. 7)

This division, the first to be placed in active construction, is now 85 per cent. completed, and will be finished well within the estimate, both as to time and expenditure. This result has been accomplished chiefly through the efforts of the efficient organization maintained by A. C. Hansen, division engineer.

On this division 37,115 lineal feet of covered conduit have been excavated and lined to date, being 98 per cent. of the total. The small amount remaining is situated on fills between tunnel portals, and is being left to the last possible moment in order to eliminate all danger of cracking from settlement. 64,724 lineal feet of tunnel, which is 99 per cent. of the total tunnel footage, have been excavated. 54,672 lineal feet of tunnel have been lined with concrete, leaving 10,470 feet still to be taken care of. The major part of the tunnels on this division have been fairly easy to excavate, the material encountered varying from soft sandstone to moderately hard and blocky granite. In Tunnels Nos. 35, 38 and 39, situated between Jawbone and Pine Canyons, considerable water has been encountered, and it has been difficult to keep the timbers in place. The practice has been followed of concreting these tunnels as soon as possible after excavation, which has obviated further difficulty with swelling ground.

Of the four siphons necessary for the conduct of the water across intervening canyons, the smaller two at San Antonio and Dove Springs are now in process of construction. These particular siphons are steel pipes, 9 feet in diameter, built of ¼-inch steel plate, connected with the conduit proper by suitable reinforced concrete junction bays. The Lacy Manufacturing Company of Los Angeles are the contractors for this work, which it is expected will be completed at an early date.

Mojave Division (No. 8-A)

The scope of this division, which originally extended only from Pinto to Cottonwood Creek, has been extended to include both the North and South Antelope Divisions, and now embraces all territory from the south end of the Jawbone Division to the Fairmont Reservoir, under the supervision of A. J. Ford, construction superintendent.

Two steam shovels, owned and operated by the City, have been constantly at work, followed by the usual concreting crews.

Shovel No. 4, originally built to operate by means of gas engine power, has been remodeled to the standard steam type, and has been employed on the North Antelope section, both above and below the Sand Hill tunnels.

Three miles of tunnel have been excavated at a cost of less than $10 per foot for labor and supplies. Continuous trackage has been laid through these tunnels, and gasoline locomotives designed and furnished, in order that concrete materials may be hauled from the Cottonwood Wash to the stretch of conduit lying between the south end of the Sand Hill tunnels and the Antelope Valley siphon. This particular part of the location, in spite of thorough prospecting, is found to be almost totally lacking in rock and gravel.

The following figures show the total progress to date on this section:

		Lining		
Conduit.	Excav.	Bottom.	Sides.	Cover.
Mojave Section	91.659	76,253	77,846	77.104
No. Antelope	12,272	9,521	9,521	9.521
	103,931	85,774	87,367	86,625
Tunnel	15,652	1,603	1,771	1,771

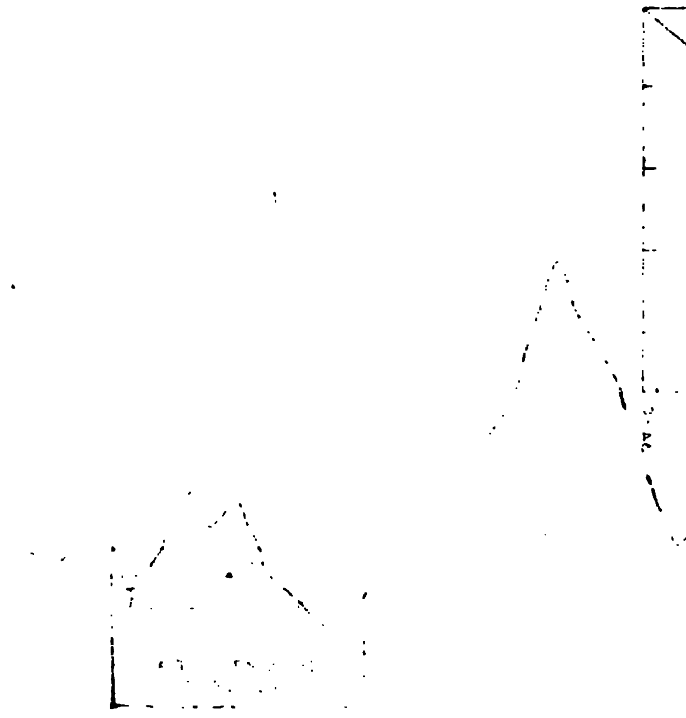
The portion of this division known as the South Antelope section is covered by the contract let to P. A. Howard. Progress on this work has been somewhat delayed on account of adverse weather conditions during the past winter, but it is now going ahead in a satisfactory manner. The following table illustrates the amount of footage completed to date on this contract:

		Lining		
	Excav.	Bottom.	Sides.	Arch.
Tunnel	1,344	1,344	1.344	1,344
	Excav.	Bottom.	Sides.	Cover.
Conduit	31.500	30,850	30.850	30,850

All cement for both North and South Antelope Valley sections is furnished by Tufa Mill No. 1, an auxiliary plant for the manufacture of modified cement, equipped with a ball and tube mill and the necessary motors. Electric power is furnished by the Edison Electric Company. The total output during the year was approximately 21,500 barrels.

Elizabeth Division (No. 10)

The completion of the Elizabeth Tunnel was formerly considered to be the controlling factor as to the time required for the delivery of water by the Aqueduct. It has now been demonstrated by the progress attained during the past twelve months,



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that it will be feasible to complete this work in approximately three-fifths of the allotted period. This result has been rendered possible only by the high efficiency of the organization maintained by tunnel superintendents John Gray and W. C. Aston, in charge respectively of the north and south portals. Remarkable records of monthly progress have been accomplished at both portals, a total of 567 feet of excavated tunnel being achieved at the North Portal by John Gray during May, and 604 lineal feet by W. C. Aston at the South Portal during April, 1910. The latter run is the American hard rock record for tunnel work. It is estimated, however, that the difference in material encountered being taken into consideration, the high runs at each portal represent practically the same amount of work. The difference in ground at the separate portals has been very marked, that at the north end requiring sets of 8x8 timbers spaced from 2 to 8 feet apart with close lagging to prevent caving, while practically no timbering is required at the South Portal. Fully 20 inches of seepage water is accumulated in sumps at the north heading and pumped to the portal, while at the south end the small amount of water encountered is taken care of by the tunnel grade.

An interesting fact regarding the driving of the tunnel, and one which reflects great credit on the men in charge, is that the footage cost since the opening of the portals, has steadily decreased instead of increasing, as might be supposed natural under the circumstances. 10,705 lineal feet of excavation have been accomplished to date from the North Portal, and 10,810 lineal feet from the South Portal, making a total of 21,515 lineal feet accomplished to July 1, 1910, leaving a remainder of 5,345 feet, which will probably be completed during the coming year.

A complete concreting outfit has been installed at both portals, together with a sufficient quantity of steel forms, for lining purposes. It is probable, however, owing to the unexpected progress in excavation, that all lining operations will be deferred until the tunnel is finally "holed."

Saugus Division (No. 11)

The total length of the Saugus Division, from the intake at the proposed lower San Francisquito power house to the point of drop into the San Fernando Valley at the south end of Tunnel No. 108, is 15.1 miles, of which 48,434 feet is in tunnels, 11,468 feet in covered tunnel section, 16,262 feet in siphons, and 3,884 feet in reservoir. Of this, there has been excavated 47,434 lineal feet of tunnel, 10,744 feet of conduit and 955 feet of siphon trench.

The material encountered in tunnel excavation has been almost entirely indurated earth or sandstone. Tunnels Nos. 73 and 104 were practically the only exceptions, the former being driven through a ledge of water-bearing slate, while the latter developed a considerable area of oil shale requiring close timbering and the driving of overhead spiling to protect the men. Exposure to the air caused swelling of the ground and consequent destruction of timbers, to prevent which the entire area affected was lined with concrete. Close inspection of this lining has failed to reveal any signs of rupture. The total amount of concrete lining accomplished to date on this division aggregates 35,056 feet, divided as follows:

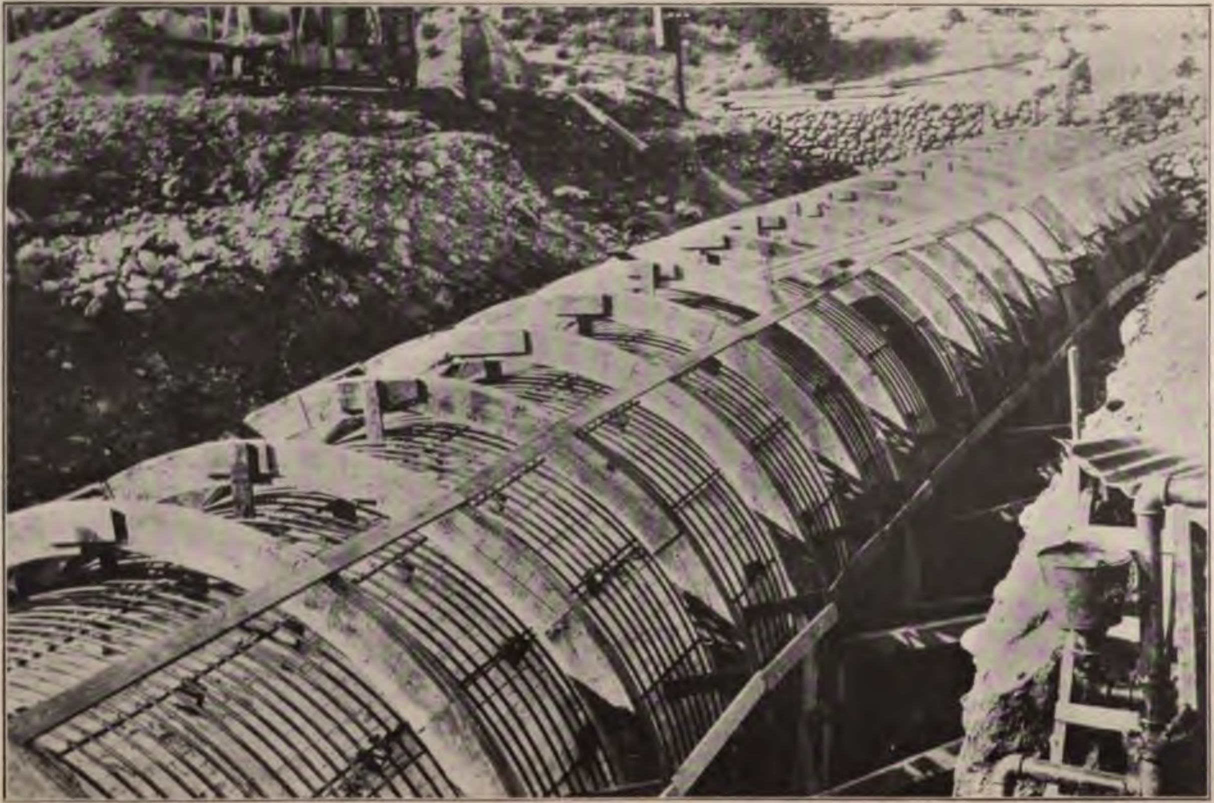
Tunnel	29,936 feet
Conduit	4,165 feet
Siphon	955 feet

Good progress is being made on the excavation of the core-wall trench for the Dry Canyon dam. This dam, situated at the end of the power tunnels, will create a small reservoir of 1,325 acre feet capacity to be used only for flow regulation. Soundings have demonstrated the presence of bedrock at an average depth of 75 feet. It is proposed to excavate this trench to bedrock if possible, and if not, to within 15 feet of the required depth, and drive sheet piling to a firm foundation. The trench, 6 feet in width, will then be filled with concrete to the ground surface. Estimates for the dam, exclusive of core wall construction, call for the moving of 164,000 cubic yards of earth, which will be deposited in place by the hydraulic process.

An interesting feature of work on this division has been the construction of a reinforced concrete siphon in Whitney Canyon. This siphon, designed to operate under a maximum head of 65 feet, is 955 feet long with an interior diameter of 120 inches. The concrete shell is 9 inches in thickness, being reinforced with circumferential rods spaced 4 inches apart and placed 3 inches from the outer surface. Longitudinal rods are spaced 24 inches center to center. Thirty days after the last concrete was placed, the pipe was filled with water, and found to be absolutely tight and satisfactory.

Similar construction will probably be used on other low head siphons, as such pipes can be built for approximately $5 per foot less than steel siphons, and have the advantage of improving, instead of deteriorating with age.

All work in the Saugus Division has been done under the direct supervision of D. L. Reaburn, division engineer.



WHITNEY SIPHON, SAUGUS DIVISION. DIAMETER 10 FEET.

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AQUEDUCT FOOTAGE, July 1, 1909 to July 1. 1910

TOTAL AQUEDUCT FOOTAGE

DIVISIONS	CANAL	SIPHONS		OPEN CONDUIT		FLUME	TUNNELS		COVERED CONDUIT		PENSTOCK	TOTAL AQUEDUCT FOOTAGE						
	Excavation	Excavation	Completed Steel or Concrete	Excavation	Lining	Complete	Excavation	Lining	Excavation	Lining	Haiwee	CANAL	SIPHONS	OPEN CONDUIT	FLUME	TUNNELS	COVERED CONDUIT	PENSTOCK "HAIWEE"
Owens Valley	49510			151	151							110800		111400				
Olancha				16309	12221									97000				
Rose Valley																	68927	10558
Little Lake							18587	175	1834				3417			35537	16460	
Grapevine							15011		12387	10676			4773			30233	28303	
Freeman							2357		64604	64843					300	2874	101270	
Jawbone		1727	648			300	18878	44399	12267	20312			13978		535	65113	38804	
Mojave									40388	37415							148759	
No. Antelope						99	11062	1771	11827	9521			21800		99	15652	44282	
So. Antelope							524	1344	25901	27738			2523			1650	58930	
Elizabeth							11317									26860		
Saugus		955	955				26287	26917	3286	4769			16200			48443	11463	
Total Feet	49510	2682	1603	16460	12372	399	104023	74606	172494	175274		110800	62691	208400	934	226362	517198	10558
Total Miles	9.37	0.50	0.30	3.12	2.34	0.07	19.70	14.13	32.67	33.20		20.98	11.87	32.57	0.18	42.90	97.97	2.00

TOTAL EXCAVATION, July 1, 1909 to June 30, 1910 65.36 Miles

TOTAL LINING, July 1, 1909 to June 30, 1910 50.04 Miles

PROGRESS ACCOMPLISHED PRIOR TO JULY 1, 1909

Feet	12892						88397	14758	91521	51794	
Miles	2.45						16.74	2.80	17.33	9.81	

Total Excavation Prior to July 1, 1909 36.52 Miles

Total Lining Prior to July 1, 1909 12.61 Miles

TOTAL PROGRESS ACCOMPLISHED TO JUNE 30, 1910

Feet	62402	2682	1603	16460	12372	399	192420	89364	264015	227068	
Miles	11.82	0.50	0.30	3.12	2.34	0.07	36.44	16.93	50.00	43.01	

Total Excavation to June 30, 1910 101.88 Miles

Total Lining to June 30, 1910 62.65 Miles

CEMENT PLANT.

The camp at Monolith has grown to the proportions of a fair-sized village. Ten frame bunk-houses and fifteen framed tents have been provided for workmen without families, while twenty-five frame dwellings have been constructed for rental to married employees. There is a general store, a mess-house, a hospital and a reading room, as well as a school-house for the children of employees. Sanitary conditions have been insured by the establishment of a complete sewer system. The general health of the camp during the year has been excellent. Additions and improvements have been made as follows:

A warehouse 40x100 feet has been built for the storage of sacked cement, with a capacity of 20,000 barrels.

An automatic weigher and sacker has been installed, with a capacity of 200 sacks per hour.

The warehouse for stores and supplies has been enlarged to twice its original size.

One ball mill and 4 tube mills have been added to the number originally installed, making a total of 7 ball mills and 13 tube mills. This extra installation is for the purpose of grinding tufa rock to mix with the ordinary mill product. Large deposits of tufa have been found close to the mill, and as laboratory tests and actual experience have shown excellent results from this mixture, the use of this machinery will enable a much larger output to be attained at a considerably less cost per barrel. Contracts for two steel framed buildings and a tufa rock dryer have been made in connection with the foregoing improvements and will be erected in the near future.

Considerable difficulty was experienced during the winter months in securing sufficient raw material, owing to the unprecedented rain and snowfall and consequent adverse conditions. The clay deposit, ordinarily dry, was flooded to an average depth of 4 feet, necessitating the construction of a dredge and greatly hampering the operation of the machinery, which was built for dry or semi-dry material. The condition has been improved by natural drainage and evaporation,—but it is proposed to prevent any recurrence by the construction of a plant for pumping fluid clay to settling ponds, in which an adequate supply for a year's run can be stored, if necessary.

The supply of lime rock has, during the past year, been obtained at the South Meehan quarry, being transported by aerial tram and surface railroad to the crusher. The City's title to the Cuddeback quarry now being perfected, and development work having shown that there is an enormous deposit of rock of high quality which can be economically worked, it is probable that a surface road will be built to this latter point. It is estimated that by this means the cost of limestone can be cut in half.

The total output of the Monolith mill during the fiscal year was 209,700 barrels of ground cement. There is, in addition, 42,300 barrels of clinker in storage ready for the final grind.

The excellent results accomplished at this plant, together with the steady decrease in operation costs, have been rendered possible by the efficient management of Roderick MacKay, mechanical constructor.

The expansion of the work during the past year having demanded more cement than could be supplied by the City plant, competitive bids were called for this extra supply. These bids being uniformly high were all rejected, and arrangements were finally made with the Riverside Portland Cement Company for the delivery of 100,000 barrels, with an option on an additional 100,000 barrels, at a price of $1.45 per barrel delivered at Mojave, Saugus and intermediate points. Approximately 125,000 barrels of this cement were used during the year, giving general satisfaction.

TUFA CEMENT.

The plan of manufacturing modified cement, as outlined in the Third Annual Report, has been followed and has proved to be an unqualified success. As mentioned in the reports of Divisions 3-A and 8-A, regrind plants have been established at Haiwee and Fairmont, and the product from these plants, used exclusively in the immediate vicinity, has proved very satisfactory.

The average of tests made at the Monolith laboratory for both Fairmont and Haiwee tufa, is as follows:

	3 days.	7 days.	28 days.	3 mos.
Fairmont Tufa.				
Breaking Strength in lbs. per sq. in.........	85	185	305	420
Haiwee Tufa.				
Breaking Strength in lbs. per sq. in.........	100	140	280	355

The above tests were made from a mixture of 50 per cent. Monolith Portland cement, and 50 per cent. ground tufa by volume, reground to a fineness of not less than 90 per cent. passing a 200 mesh sieve. The resultant product was then mixed with 3 parts of standard sand.

This showing compares favorably with cement tests of any standard brand, and indicates a product which grows steadily in strength and resisting power.

The economy resulting from the use of modified cement ma be more readily realized when it is understood that two barre of such product may be manufactured from each barrel of straig Portland cement by the addition of ground tufa rock. Thus, tl cost of one barrel of modified cement is represented by the expen incurred in quarry and regrind operation, plus the cost of one-ha barrel of straight Portland cement at the mill. Carefully ke cost data show this figure to be practically 70 per cent. of the co of the straight material.

This saving alone would justify large expenditures for equi ment installation, but by far the largest economy effected is tl saving in freight and wagon transportation charges, the form item being reduced 50 per cent. Extensive field use, in additic to thorough laboratory tests, has shown the tufa cement to l equal, if not superior, to any hydraulic cement on the market.

An interesting experiment was made at the Monolith mi based on the idea of substituting tufa rock for clay. While tl trial run was not entirely satisfactory, it was demonstrated th with a few changes in equipment and the addition of a proper flu a first-class grade of Portland cement could be manufactured in th way. As the tufa deposits adjacent to the mill site are practicall inexhaustible, it will be readily seen that this adds another valuabl asset to the property.

Office Organization

The organization of the Los Angeles office continues formerly outlined in the report of 1909, with E. W. Bannister office engineer, S. B. Norton as chief clerk and O. W. Clemen cost-keeper.

Special attention has been given during the past few montl to the preparation of profiles and specifications for the constructic of the steel siphons or pressure pipes, designed to convey tl conduit flow across the various canyons encountered. As tl weight of this steel will approximate 16,000 tons, it is expected th the contract for this installation will attract the largest manufacturers in the country, securing sufficient competition to insu the delivery of the necessary material at a very economical figur

Cost Data

Careful cost data are being kept on all units of the work. Eve class of work which will be encountered in the building of tl Aqueduct has been undertaken. Estimates are being made at i tervals of six months on the cost of the finishing the Aqueduc

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based upon past experience. From these estimates it is believed that the work can be completed within the original estimate.

It is impossible to predict labor conditions in advance. Scarcity of labor not only involves a higher price for labor, but less efficiency in that which is obtained. For this reason, it is impossible to make absolute predictions of cost. Progress diagrams have been prepared for all features of the work, running schedules being established for each steam shovel and for each long tunnel. Up to May 20, 1910, the work was progressing at a rate that would have completed the Aqueduct by the 1st of May, 1912. During the spring of 1910, expenditures were being made at the rate of nearly $600,000 a month in order to keep up this schedule. About May 20th, some difficulty occurred in connection with the disposal of the Water Extension Fund bonds, and the work had to be reduced to a basis of $160,000 a month. It was maintained on this basis during the months of June and July, the organization being reduced from 3,800 to 1,100 men. This disorganization, coupled with the fact that it is naturally difficult to retain labor on the desert during the summer months, has seriously interfered with the progress schedule and the cost estimates. It probably will not be possible to reorganize up to the 3,800 men basis before the cool weather of the fall, and while every effort will be made to expedite the work, it can hardly be expected that this interruption of the schedule will not delay the date of final completion of the Aqueduct.

Final arrangements are now being completed which contemplate the prosecution of the work on the basis of an expenditure of about $300,000 a month from the first of August, 1910, to the first of February, 1911. This necessarily will result in a materially slower schedule than that planned for the completion of the Aqueduct in the spring of 1912.

Railroad Transportation

One of the most important factors in the successful prosecution of the Aqueduct work has been the rapid construction of the California and Nevada Railroad, which practically parallels the conduit location north of Mojave, making possible the establishment of supply depots at points comparatively adjacent to the various scenes of operation. Complete systems of team and traction engine transportation, on each division, have served for the delivery of construction materials at a reasonable ton mile cost.

Although the contract between the City and the Southern Pacific Company only called for completed trackage to Little Lake, Inyo County, during the past fiscal year, the road was opened to operations as far north as Haiwee during the fall of 1909, and daily trains are now running to Siding No. 28, which is one hundred and forty miles north of Mojave, with grading finished as far as Cottonwood Creek.

The change in the location of the railroad from the east to the west side of Owens Lake will greatly facilitate operations through the Alabama Hills and Owens Valley sections, the shortening of the wagon haul allowing more prompt and economical delivery of materials and supplies. The construction of this line is of the most permanent character, heavy steel being laid, and the road-bed fully ballasted. Special attention has been paid to the elimination of grades and curvature,—heavy cuts and fills, together with a mile of continuous tunnel, being accepted in the vicinity of Little Lake and Searles.

Location Revision

Since construction work on the Aqueduct began, detailed studies have been made of the physical conditions, both during the construction and subsequent thereto, such as the passage of floods over covered portions of the Aqueduct and the like, and accurate cost has been kept on all features of the work.

Taking all this data into consideration, E. A. Bayley, assistant engineer, has reviewed practically the entire line of the Aqueduct, with the view of attaining most substantial construction and maximum economy. The effect of this study has been to substitute tunnels for steep side hill work in mountainous portions of the line, which it has been found could be done without materially increasing the cost, and also to throw the valley portion of the conduit into deeper excavation at all points where drainage lines are crossed, so that the effect of floods is rather to make deposits of sediment on top of the cover of the Aqueduct than to make erosions on the lower side. It is believed that the line has been substantially improved in this manner.

ELECTRICAL DEPARTMENT.

Power for Construction.

General Description

There have been but slight additions to the electric power systems during the past year. These consist mainly in the extension of the 33,000 volt line from the north portal of the Elizabeth Tunnel to the Fairmont Tufa Mill, 3.7 miles north, and in various short branches connecting with transformer stations along the main line, aggregating several miles, most of which are in the Little Lake and Grapevine Divisions.

By way of a brief review it may be stated that there are two independent systems of distribution for power along the Aqueduct. The first, known as the Saugus System, extends from the south end of Fernando Tunnel to the Fairmont Tufa Mill, and is connected with the Castaic sub-station of the Southern California Edison Company, making a total of approximately forty miles of 33,000 volt transmission, having connected to it nine step-down transformer stations, consisting in all of six 125 kilowatt, three 75 kilowatt and ten 40 kilowatt 33,000 volt transformers, stepping down to either 440 or 2200 volts, as may be desired, 440 volts being practically universal. The second power system, known as the Cottonwood System, extends from the intake along the line of the Aqueduct to the Pinto Hills, a distance of approximately 147 miles, and from the Pinto Hills seventeen miles west to the Cement Plant, making in all, with branches connecting the Division Creek and the Cottonwood Creek Power Plants, 166 miles of 33,000 volt transmission. 146 miles of line is made up of three No. 4 copper wires and seven inch, two-part porcelain insulators on 30-foot poles, the remaining 20 miles being of No. 2 copper wire. Branches to transformer stations, aggregating some twelve miles, are constructed of No. 6 copper wire on 25-foot poles. To these lines are connected numerous step-down transformer stations, with a total installation of three 250 kilowatt, three 100 kilowatt, nine 75 kilowatt, forty-one 40 kilowatt and fourteen 20 kilowatt 33,000 volt transformers. All step-down transformers are the oil insulated, self cooling type. About one-half, or the later purchases, are a portable outdoor type, in boiler iron cases, with covers made oil as well as water tight. These were furnished in accordance with the City's specifications, and are giving excellent satisfaction, in addition to their great convenience, especially in shovel and mixer work. Nearly all transformers were shipped with oil in them, thus avoiding the inconvenience of drying out at isolated points along the line.

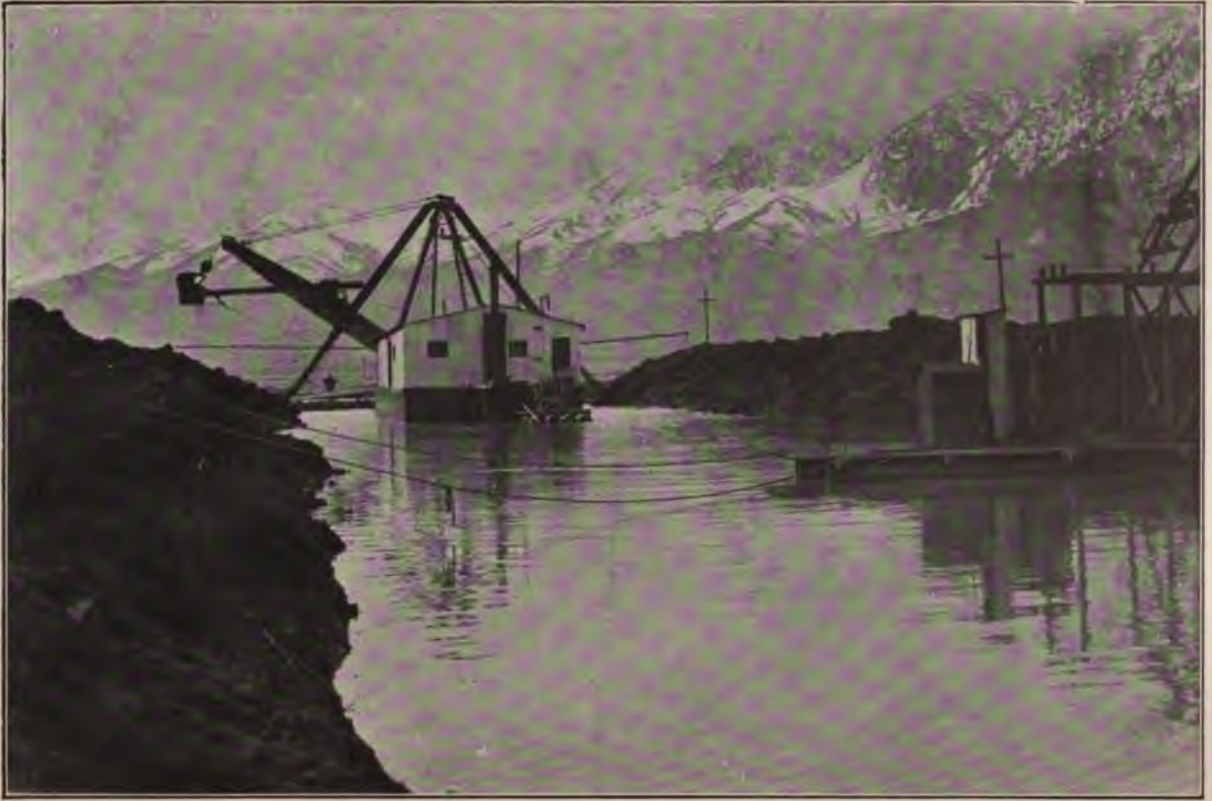
The Cottonwood System is supplied by three hydro-electric plants, Division Creek No. 1, 125 kilowatts; Division Creek No. 2, 600 kilowatts, and Cottonwood Creek Power Plant, 1500 kilowatts rated capacity, with 25 per cent. continuous overload capacity. Division Creek No. 1 was originally isolated, and was installed for the purpose of starting the dredging in Owens Valley at an early date. These plants run in parallel with the Cement Plant steam power, consisting of two 750 K. V. A. Curtis turbine units. This supplements the steam plant, which is otherwise insufficient, adds to the stability and flexibility of the whole power system, and results in a saving of fuel oil at times during the day when there would otherwise be an excess of hydro-electric power.

Amount of Power

Saugus System.—Electrical energy for the Saugus System is supplied by the Southern California Edison Company, being delivered at their Castaic sub-station at 33,000 volts. Up to the end of June,—4,472,316 kilowatt hours have been delivered at this point, and meters show 3,912,170 kilowatt hours as having been delivered at 440 volts at various points along the line during the two years and three months that this system has been in operation.

Cottonwood System.—The Cottonwood System began to deliver power to the Jawbone Division in November, 1908, and to the Cement Plant in June, 1909. Meters show a total delivered to the end of June, 1910, of 4,027,000 kilowatt hours to the Cement Plant, and 5,369,395 kilowatt hours to various points between the intake and Pinto Hills for dredges, electric shovels, tunnel stations, etc.

The connected load between the intake and Pinto Hills, with work at its height, is represented by the tabulation below as aggregating 3470 horsepower. The connected load due to lighting, machine shop motors and other such small requirements is not tabulated, but is, of course, supplied from this system. In many instances the power is used twenty-four hours a day, in others sixteen or eight hours, with average about sixteen hours a day. The usual load at the switchboard for supplying this system during the heavier periods of the day, exclusive of the Cement Plant, is 2000 horsepower, while the average for twenty-four hours would be about sixty per cent. of this. Hence, the power requirement for construction of this character and such a connected load is shown. It should be understood, of course, that during the complete period of Aqueduct construction the average connected load will be considerably less than this. During the first six months, for example, it was not over one-quarter of this amount.



DIPPER DREDGE WORKING IN MAIN CANAL, OWENS VALLEY DIVISION.
(Reproduced from First Annual Report of Bureau of Los Angeles Aqueduct Power.)

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MOTOR INSTALLATION INTAKE TO PINTO HILLS.

2 suction dredges	400-HP
1 dipper dredge, 1½-yard dipper	100-HP
4 electric shovels, ¾-yard dippers	300-HP
Tufa regrinding mill	200-HP
Haiwee Dam, hydraulic work	100-HP
8 air compressors, 500 cu. ft. each	800-HP
8 motor generators, 80 K.W. each	1000-HP
7 rock crushers, 10 and 20 tons per hour each	140-HP
28 concrete mixers, 6 and 10 cu. ft. per batch	280-HP
7 blowers, 1350 cu. ft. per minute each	70-HP
3 hoists	60-HP
2 pumps	20-HP
Total rated capacity of motors	3470-HP

Cost of Electric Power

In the Third Annual Report it was stated that "Preliminary estimates and study showed that, for those sections in which the work is heavy and the power requirements considerable, electrical energy could be generated at certain central points and delivered at the work at a lower cost and with more satisfactory results than could be realized by the distribution of the necessary generating machinery and fuel along the line. It was further shown that hydro-electric power could be developed along the Division Creek and the Cottonwood Creek and delivered to all points from the intake in the Owens Valley to the south end of the Jawbone Section, giving reliable power at from one-quarter to one-third less cost than it could be furnished in any other way. In each case, interest on the investment and total depreciation of the systems, with the exception of a reasonable return from the machinery and copper, were included in the costs."

The hydro-electric plants themselves were built of a permanent character with best machinery, as their continued use will be required at times in connection with the operation of the Aqueduct, and they will be a valuable addition to the City's future hydro-electric power developments along the Aqueduct, therefore, only interest and usual depreciation is being charged against them in connection with construction work, but full depreciation, with the exception of salvage, is charged against the distributing lines, step-down transformer stations, etc.

To be more specific, the early estimates, referred to, show a cost of 1.75 cents per kilowatt hour delivered in the Jawbone Section from a single steam plant at Cameron for that purpose; oil valued at 75 cents per barrel. Oil is costing us $1.25 per barrel at that point, and this would have made the cost over 2 cents per kilowatt hour delivered at Jawbone Tunnel stations from the steam plant. A similar steam plant and distributing system for the Grapevine and Little Lake Divisions would have resulted in a cost of over 3 cents per kilowatt hour delivered at step-down voltage at those tunnel stations, as the cost of oil delivered in that section is not less than $2.50 per barrel. This would have been for the sections using the greater amounts of power, no provision being made for the many miles along which smaller amounts of power are used. Experience has shown that distillate engines give very unsatisfactory results for these small amounts of power because of lack of reliability operating under the conditions existing there, though in the hands of good mechanics, as it is all hustle and the engines are necessarily moved from place to place in a windy country with dust always in the air from construction work. The original estimates lead to the expectation that the hydro-electric system, which has been installed, would result in a cost per kilowatt hour for electrical energy, delivered in larger and smaller quantities at all places along the line requiring power, of 1.15 cents per kilowatt hour at 2200 or 440 volts. The results to date indicate that this was a safe estimate, and that the cost will be well within 1.15 cents for all hydro-electric power delivered from the intake to the Cement Plant at step-down voltages, and had the hydraulic plant been constructed of a temporary character and a full depreciation allowed, the cost of power would still have been very much less than that for which it could have been furnished in any other way, and very much more reliable, which appreciably affects the economy with which construction work can be done.

Saugus System.—The price paid the Southern California Edison Company for electrical energy for this system varies somewhat in accordance with daily load factor, but averages 1.2 cents per kilowatt hour. It is charged against the work at 1.85 cents per kilowatt hour delivered at 440 volts in large and small quantities, the difference being intended to cover the losses of energy in distribution and the total cost in the end of constructing and maintaining a distributing system, with interest, and less its salvage value. As far as can be told to date this charge is approximately correct, and from what has been stated above is evidently considerably cheaper and at the same time more reliable than power furnished in any other way.

TELEPHONE SYSTEM

The main line telephone, extending from the Los Angeles offices along the Aqueduct to the intake in Owens Valley, has been described in previous reports, together with the desirability and necessity for the same in the operation of power systems and in constructing the Aqueduct with economy and dispatch. It is approximately 240 miles long and consists of two No. 10 copper wires supported to D. P. D. G. glass insulators on 4x6-18 and 20 foot redwood poles, entirely clear of all power lines, and is divided in three sections by exchanges at Mojave and the Cottonwood Creek power house.

Local systems, which have also been described in previous reports, are located in the various divisions, there being but one main line phone per division. The local systems may be switched on to the main line temporarily if desired. No. 12 iron wire is used for the local system and is placed either on the main line poles or on separate telephone poles entirely independent of the power lines for safety in their use. Approximately 55 miles of additional local lines have been built during the past year, making in all approximately 220 miles of local lines.

All telephones are connected in multiple; that is, bridged across the line; have a resistance of 2500 ohms; a five-bar magneto, and local batteries at phone.

PERMANENT HYDRO-ELECTRIC POWER

The opportunities for developing large qauntities of hydroelectric power along the line of the Aqueduct have been described in previous reports. The City Charter places the development of this power in charge of the Board of Public Works, and in accordance with a recommendation by the Board, a bureau in the Department of Public Works was created by ordinance in September, 1909, and termed the Bureau of "Los Angeles Aqueduct Power." William Mulholland, chief engineer of the Los Angeles Aqueduct, is attached in a supervising and directing capacity, and E. F. Scattergood is chief electrical engineer. Preliminary engineering work is under way leading to the determination of general plans for the development and delivery of all power and to detail plans and specifications for the first installment, of about one-third, which it is expected will be developed ready for operation at the completion of the Aqueduct.

W. F. Durand, O. H. Ensign and Harris J. Ryan, who constitute a consulting board, state in a preliminary report that with the

400 second feet average flow in the Aqueduct, as anticipated, an average of 64,000 horsepower, with provision for a peak load of 120,000 horsepower, may be delivered in the City at a step-down voltage for $60.00 per delivered horsepower of peak load capacity. The report further states that its reliability, with the several plants, should be such that the installation of an auxiliary steam plant would not be justifiable, and states very clearly the facts on which these findings as to cost and reliability are based. This preliminary report by the Consulting Board will be published in conjunction with this year's annual report of the Power Bureau.

E. F. SCATTERGOOD,
Electrical Engineer.

WATER SUPPLY INVESTIGATIONS IN OWENS VALLEY

By Chas. H. Lee.

The Chief Engineer in May, 1908, detailed the writer to make thorough investigations of water supply conditions throughout the drainage area of the Owens River, and to make a special study of the underground water supply, as to its amount and availability. These investigations have now been in progress for two years, and much valuable data have been gathered and analyzed. The information is already showing its value, for it has made possible a more practical use of the government stream-gaging than formerly, and proved the existence of an underground storage reservoir and natural regulator which will be of great usefulness to the City in providing its future water supply.

The final results of the investigations will not be available until the end of another season, as there are still some elements of the problem which need further study. There will be presented here a summary of surface water supply conditions during the past two seasons, an outline of the underground water studies, and a summary of the results of chemical analyses of Owens Valley waters.

Surface Water Supply

The first and third annual reports of the Los Angeles Aqueduct have contained, under the Hydrographic Report, tabulations and discussions of stream flow data up to the end of the year 1908. Since that time the U. S. Geological Survey has kept up the full number of stations listed on page 90 of the Third Annual Report and also the Owens River station at Whitney Bridge. The results of the Government gagings during the year 1909 in the region adjacent to the Aqueduct are given in Tables 1 and 2.

The run-off of the season 1908-9 for streams from Taboose Creek south was above the five-year normal for the seasons 1904-5 to 1908-9 by about 20 per cent. The record of flow of Kings River during the season 1908-9 is not yet available, so that a comparison cannot now be made with the long term mean. The four year mean run-off for Kings River for the seasons 1904-5 to 1907-8 was 21 per cent. above the nineteen year normal, and with a fifth year of large run-off added, this percentage would not be reduced any. It is, therefore, probable that the 1908-9 seasonal run-off was between 40 and 50 per cent. greater than the long term normal run-off, for Owens Valley streams south of Taboose Creek. Stream flow data for the Owens Valley are, therefore, incomplete so far as dry years are concerned.

The mass curve study of supply and demand at Haiwee Reservoir has not been continued as in previous reports on account of the obviously ample supply during the year 1909. . Detailed studies are in progress, however, which involve the investigation of supply and demand, not only at Haiwee Reservoir, but at Tinemaha and Long Valley reservoirs. These studies are based on the daily flow available at each reservoir, and where possible, the daily draft, and cover the period January 1, 1904, to December 31, 1909. Instead of assuming that the Aqueduct will pick up the total measured discharge at the U. S. Geological Survey gaging station, they assume that the waste and purchased rights only will be available on streams south of Taboose Creek. They also involve a detailed investigation of the irrigation draft in the vicinity of Bishop and Big Pine. The results of these studies are not yet available.

Underground Water Supply

The popular conception of underground water, as to its source and the manner in which it occurs and flows, is usually rather hazy, and an attempt will be made here to state the general ideas and principles relating to it as illustrated by conditions in the Owens Valley.

The system of channels formed by a river and its tributaries occupies a portion of the earth's surface girdled by an elevation of land known as a watershed. The area thus enclosed has a general slope toward some common point of outlet, and is known as the drainage basin or catchment area of the river. Generally speaking, the source of all water appearing within a drainage basin is the precipitation upon that area. A portion of this precipitation is lost by evaporation into the air, another portion sinks into the ground and the remainder appears in surface streams.

If the precipitation is upon a relatively non-porous material, such as unfissured granite, very little sinks into the ground, and water appearing in a stream draining the area represents the difference between total precipitation and evaporation within the non-porous area. On the other hand, if the material is porous, all the precipitation may evaporate and sink into the ground, and then the immediate contribution to stream channels will be nothing. This does not necessarily mean, however, that the water is lost from the drainage area, for the portion sinking into the ground flows through the porous material in the general direction of the adjacent surface stream, and may reappear in a lower portion of the drainage area in springs, seepage into channels, and swampy or damp meadow land, or else traverse the drainage area entirely as an underground flow. With few exceptions, it may be said that all of the water within a given drainage area, whether in surface channels, in springs or underground, has its source in the precipitation upon that area.

The clear understanding of local underground water conditions in Owens Valley, however, requires somewhat broader conception of the structure of a drainage area. Instead of a portion of the earth's surface with a wide range in its ability to absorb water, it can be considered as an impervious rock basin which is covered with loose alluvial material in certain portions and is bare of all covering in others. These accumulations of debris are very porous, probably 25 to 30 per cent. of their volume being void space, and it is this condition and an ample water supply which accounts for the presence of water in the immense valley fill of the Owens Valley. This rock basin is, in reality, a great reservoir or lake which has been filled with particles of gravel and sand, and as its general behavior corresponds with that of a surface reservoir, it can be called an underground reservoir.

There is one radical difference between these two types of reservoirs, however, which is caused by the laws governing the motion of water through porous material, which act in opposition to the laws of gravitation. The reservoir is replenished by the absorption of water reaching the surface of the valley fill. Due to the great difference of elevation of this surface, and the slow progress of percolating waters, these accretions cannot at once reach the level of lowest ground water surface. As a result, the surface is not a horizontal plane, but has a more or less steep gradient from the outer edges towards the region of lowest elevation in the reservoir, and there is a continual movement of water in that direction with a velocity varying with pressure, gradient, porosity of the material, etc. Generally speaking, the motion is progressively slower from the borders toward the region of lowest elevation. The result of this condition is to balance up the annual and monthly irregularities and to render the rate of supply to the reservoir practically uniform.

The relations of inflow and outflow for the two types of reservoirs are identical, however. If inflow is less than outflow, there is depletion and lowering of the water surface, if inflow exceeds outflow, there is accumulation and rising of the water surface until overflow occurs, and if inflow equals outflow, the water surface is stationary. It is thus apparent that fluctuations in ground water surface are caused by changes in the relative values of inflow and outflow from the underground reservoir. It is also apparent that artificial draft on an underground reservoir supply by wells, underground galleries or other means is an overdraft when in excess of the inflow and will be registered by a permanent subsidence of the ground water surface. In other words, the yield of an underground reservoir is limited by the supply entering it, and draft in excess of this means depletion, just as in a surface reservoir.

The study of the underground reservoirs in Owens Valley was undertaken for the purpose of determining: (1) the sources of supply and their amount, (2) the value of the yield, (3) the proportion of the yield which can be made available to the Aqueduct with due regard to economic laws.

Before these quantities can be computed, the general relations between rainfall, evaporation, surface run-off, and ground water must be known, and for this purpose the following data are necessary:

1. Sources of Supply

(a) The total run-off of high mountain drainage areas.

(b) The percentage of this run-off which sinks into the ground between the mouth of canyon and Owens River.

(c) The precipitation upon the intermediate mountain slopes, outwash slopes, and valley floor.

(d) The percentage of this precipitation which sinks into the ground and becomes a part of the underground supply.

(e) The percentage of the precipitation falling upon the valley floor which flows into Owens River without entering the soil.

(f) Ground water fluctuations.

2. Total Yield (Outflow)

(a) Evaporation and transpiration from natural meadow and alkali lands, and from irrigated lands.

(b) Evaporation from water surfaces.
(c) Seepage flow into Owens River.
(d) Spring flow into Owens River.

3. The Yield Available to the Aqueduct.

The data bearing on these subjects in existence at the commencement of this work were insufficient to determine them. They consisted of measurements of surface water available to irrigation interests below Round Valley, which had been made by the United States Geological Survey since August, 1903; the meteorological observations of the regular Weather Bureau Observatory at Independence, covering a period of about twelve years; and precipitation records by co-operative Weather Bureau observers at Bishop, Lone Pine and Keeler. All of these records are available to the present date. There were also in existence United States Geological Survey topographic maps covering most of the Independence and Owens Lake regions.

The field work of the investigations involved the following:

1. Stream Gaging.

(a) Comparative measurements of the surface flow of streams draining high mountain areas to determine seepage losses between mouth of canyon and U. S. Geological Survey gaging stations.

(b) Measurements of tributary streams flowing directly into Owens River, ditches diverting from it, and continuous records on Owens River, in co-operation with the Geological Survey, for the purpose of determining the gain by seepage into the river channel.

(c) Measurements of run-off of high mountain drainage areas and springs not measured by the Geological Survey.

2. Precipitation.

The measurement of rainfall and snow upon the outwash slopes and lower margin of the intermediate mountain slopes.

3. Evaporation and Transpiration.

(a) Measurement of the evaporation from water surfaces.

(b) Studies of the evaporation and transpiration from soil and vegetation.

4. Duty of Water—Determination of the amount of water used per acre in irrigating typical farms near Independence.

5. Observation Wells—The location of all existing wells and sinking auger holes to ground water surface, over the area for which ground water data were to be gathered.

6. **Ground Water Observations**—The measurement of the depth to ground water in the observation wells, and the position of water surface in lakes, to determine the amount and character of ground water surface fluctuations and the causes thereof.

7. **Soil Absorption Tests**—The determination of the amount of available pore space in valley floor lands above the lowest ground water level.

8. **Elevations**.—The connection, by a system of levels, of all observation wells and lakes and also precipitation gages.

9. **Transit Work**.—The referencing of all observation wells, lakes and precipitation gages to the Public Survey, and the traversing of the boundaries of the meadow, alkali and desert areas in the valley floor.

10.—**Examination of Drainage Basins**.—To determine the surface conditions and establish boundaries of high mountain drainages on existing maps.

11. **Artesian Well Data**.—The recording of driller's logs and observation of flow, temperature of water, etc., for deep wells drilled along the Aqueduct line.

These field observations were made very completely and carefully in the Independence region, but in the Bishop-Big Pine region they were not as complete. The Long Valley and Owens Lake regions were examined carefully, but very little field work was carried on there.

There are several conditions which make the Owens Valley an ideal location for carrying on these studies. Among them are the regular and uniform flow of the streams, the uniform run-off characteristics of large areas, the small precipitation and few storms occurring in the valley, and the simplicity of topographic and geologic formations. These all tend to simplify the gathering of accurate data and bring it within the range of reasonable cost and human capability.

QUALITY OF WATER

The results of chemical analyses of surface waters of the Owens Valley have been presented in former hydrographic reports, and have shown this water to be of a purity above the average of that in use in California cities. In fact, the amount of dissolved salts in an average run of this water is about 50% of that found in water drawn from the mains of the City of Los Angeles at the present time.

The analyses made during the last two years have been largely of underground waters from wells and springs, and have shown that water from this source is of an exceptional purity, both as compared with the surface waters of the Owens Valley and with underground waters of other regions. This is true, not only of water flowing from deep artesian wells, but also from shallow dug wells and springs. It has been found too that the salt content of the artesian water decreases as the well continues to flow; there has been a reduction of from 17.4 to 13.5 parts per 100.000 in artesian well No. 1 during the first year of its free flow.

The cause of the great purity of the underground water may be explained by the nature of its outlet. As stated before, 75 per cent. of the underground supply of the Independence region finds its outlet by evaporation from the damp meadow lands of the valley floor. This process is a continuous one and prevents any stagnation of underground waters, or concentration of mineral matter held in solution in any portion of the valley fill other than the ground surface and the immediately adjacent soil of the meadow lands. There it is deposited by the process of evaporation, and in the course of time is washed into Owens River by surface run-off, or is blown away by desert winds. The condition on the east side of the valley where the supply is very small and there is no outlet by evaporation, agrees with this conclusion, for there the water contains a large percentage of mineral matter to considerable depths.

Generalizing, it may be said that chemically the surface and underground waters of the Owens Valley are exceptionally pure, and well adapted to the varied uses of a municipality.

MEAN MONTHLY DISCHARGE OF OWENS VALLEY STREAMS FROM TABOOSE CREEK SOUTH

YEAR 1909

Stream—	Jan. s. f.	Feb. s. f.	Mar. s. f.	Apr. s. f.	May s. f.	June. s. f.	July. s. f.	Aug. s. f.	Sept. s. f.	Oct. s. f.	Nov. s. f.	Dec. s. f.	Mean. s. f.
Taboose	4.3	4.0	2.7	4.9	8.7	25.7	22.6	10.2	5.7	4.0	3.6	5.7	8.5
Goodale	2.3	2.4	2.4	3.8	8.6	18.7	16.5	8.8	5.6	4.1	4.0	4.9	6.8
Division	7.2	6.9	7.3	7.9	8.0	16.7	16.4	15.6	14.8	13.4	12.2	11.2	11.5
Black Rock	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Sawmill	4.1	5.0	4.9	6.6	7.3	14.1	17.8	13.1	10.6	9.0	8.7	8.0	9.1
Oak	11.4	10.8	11.1	15.9	36.3	100.0	98.0	35.7	19.6	15.0	15.6	14.0	31.9
Independence	6.3	5.5	5.4	9.9	41.1	94.2	82.2	34.5	16.1	7.2	9.5	10.2	26.8
Shepard	4.7	3.0	2.5	8.8	14.8	37.9	42.2	20.6	11.0	4.7	3.0	3.0	13.0
Bairs	1.0	0.5	1.5	7.7	13.0	24.0	15.2	5.0	3.9	1.2	1.0	1.0	6.2
Georges	2.8	2.3	3.2	11.4	19.4	43.7	38.4	14.7	8.7	3.5	2.0	1.9	12.7
Lone Pine	7.2	8.4	6.4	11.9	31.5	102.0	81.1	41.4	19.6	8.6	7.8	7.9	27.8
Tuttle	5.1	6.1	6.0	7.4	11.8	26.6	29.9	12.8	10.2	7.4	7.3	14.9	12.1
Cottonwood	17.0	16.9	17.1	42.9	159.0	221.0	98.3	31.7	18.0	12.0	11.1	12.5	54.8
Ash	3.2	4.5	6.3	14.0	33.6	49.7	13.2	5.4	3.8	3.6	3.5	3.5	12.0

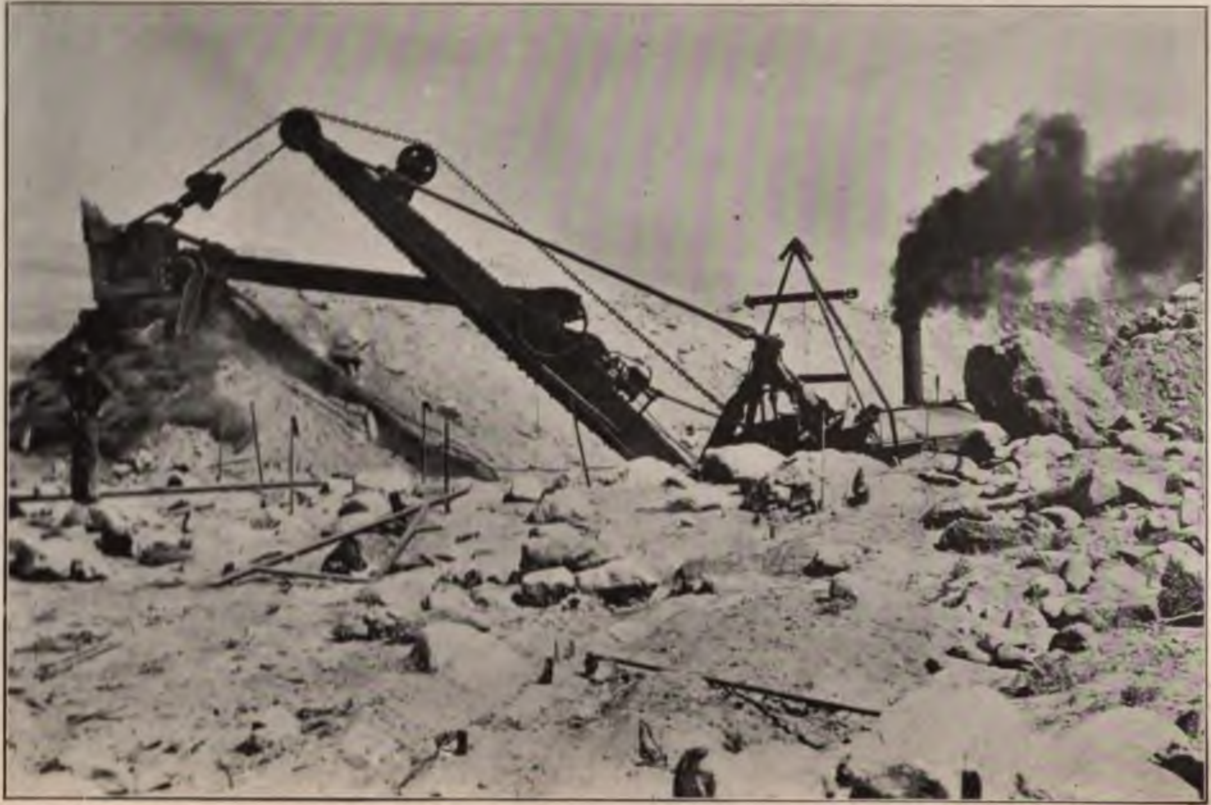
U. S. G. S. measurements. Values good.

MONTHLY DISCHARGE OF OWENS RIVER AT CHARLEY'S BUTTE AND WHITNEY BRIDGE

YEAR 1909

Month.	Discharge at Charley's Butte.				Discharge at Whitney Bridge.			
	Max.	Min.	Mean.	Total.	Max.	Min.	Mean.	Total.
	s. f.	s. f.	s. f.	Ac. Ft.	s. f.	s. f.	s.f.	Ac. Ft.
January	893	390	584	35,900	1034	422	624	38,400
February	721	430	516	28,700	913	522	653	36,300
March	430	341	378	23,200	502	385	437	26,900
April	410	121	299	17,800	422	148	323	19,200
May	264	83	143	8,800	244	75	123	7,600
June	1611	272	907	54,000	1634	260	948	56,400
July	1866	460	977	60,000	2047	574	1218	74,900
August	420	216	279	17,200	512	236	288	17,700
September	305	128	206	12,300	295	172	216	12,800
October	341	208	301	18,500	403	188	329	20,200
November	525	341	417	24,800	584	403	482	28,700
December	775	400	499	30,700	563	148	313	19,200
The Year	1866	83	459	331,900	2047	75	496	358,300

U. S. G. S. measurements. Values good.



STEAM SHOVEL WITH EXTRA LONG BOOM, DIGGING BOULDERS, OLANCHA DIVISION.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

Annual Report Store Department

LOS ANGELES AQUEDUCT

From July 1, 1909, to July 1, 1910.

Los Angeles, Cal., July 5, 1910.

To the Honorable Board of Public Works,
City of Los Angeles.

Gentlemen: Herewith I beg to hand you the report of the Store Department for the fiscal year ending June 30, 1910, compiled in accordance with instructions from your Honorable Board.

Respectfully submitted,
W. R. ORMSBY,
Storekeeper

Showing complete list of items and quantities of each item purchased by the Board of Public Works for use upon the Aqueduct, with average cost per unit of pound, hundred weight, ton, etc.; all articles of subsistence are embraced under that general head showing the gross cost; machinery covers all items that can be so construed showing the gross cost; tools, axes, hammers, saws, shovels, picks, etc., etc., by number; nails, bolts, steel, iron, hay, grain, etc., by hundred weight or ton; lumber per thousand feet; all expendable items are reported in red.

Class "A"—Tools, Carpenter, Blacksmith, etc.
Class "B"—Machinery, Renewals, and Repairs.
Class "C"—Construction Material and Supplies.
Class "D"—Electrical Equipment and Supplies.
Class "E"—Oil, Waste, etc.
Class "F"—Office Equipment and Furnishings.
Class "G"—Transportation Equipment and Supplies.
Class "H"—Cook and Bunk House Equipment.
Class "I"—Miscellaneous.

CLASS "A"

Tools

ITEMS.	UNIT	AMOUNT
"Jim Crow" Rail Benders	6	$ 74.42
Wheelbarrows	167	804.65
Wheelbarrow Repairs and Renewals		3.94
Spirit Levels	111	150.03
Tongs	28	53.48
Clevises	188¾ lbs.	9.95
Sows (Blacksmith)	3	9.00
Vises	44	351.65
Carpenter Rules and Pencils		11.68
Tamping Sticks	200	81.15
Steel Squares	2 doz.	10.76
Pliers, Pincers, etc.	284	204.86
Steel and Wood Chisels	9 1-12 doz.	27.60
Hack Saws, Planes and Blades		424.25
Blowers (Fan and Blacksmith)	7	167.34
Blowers Repairs and Renewals		.60
Hardies, Fullers, Flatters, Swedges, etc	2,148¼ lbs.	92.08
Warehouse Trucks	24	275.82
Reamers	38	47.36
Knives (Draw, Farriers)	15	5.16
Glass Cutters	10	8.12
Pinch, Lining, Claw and Crow Bars	76	80.66
Building Paper Caps and Tacks		27.38
Grind Stones	8	28.09
Grind Stones Repairs and Renewals		1.44
Oil and Whet Stones	4¼ doz.	11.42
Hoes	12 doz.	71.40
Anvils	4,142 lbs.	382.17
Packing Machine Repairs and Renewals		110.20
Pipe Cutters	13	11.61
Pipe Cutters Repairs and Renewals		41.60
Jacks and Jack Screws	86	424.40
Hydraulic Jacks	6	695.00
Hydraulic Jack Barrels	1	55.00
Well Jacks (for Water Development)	1 set	240.00
Files	681 doz.	787.92
Files, Brushes and Cleaners	66	12.90
Hatchets and Axes	37 doz.	257.12
Mattocks	4 doz.	17.60
Hammers (Handles)	704 doz.	406.74
Power Hammers	2	930.00
Power Hammer Repairs and Renewals		33.00
Riveting Hammer (Air)	3	156.00
Steel; Drill, Pick, Spring Tool, etc	107,463 lbs.	8,502.54
Steel (Sheet)	118,728 lbs.	3,026.22
Shovels and Spades	836⅓ doz.	6,589.85
Picks	32 doz.	122.40
Sprinkling Cans	½ doz.	3.13

ITEMS.	UNIT	AMOUNT
Brooms (Mill), Brushes, etc.		539.32
Drills (Hand)	4	10.15
Drills (Shank)	1,593	476.21
Braces	75	40.05
Bits	355	130.30
Augers	10	11.13
Emery Wheel Dressers, Repairs and Renewals	5	2.95
Plumb Bobs, Repairs and Renewals	8 doz.	9.52
Funnels	2	3.50
Handles (Hammer, Pick, Axe, etc.)	2,421½ doz.	4,744.55
Screw Punch (Boiler Makers)	1	28.05
Punches (Various)	97	79.82
Belting, Hooks, Lacing and Dressing		11,426.56
Wrenches (Various)	1,094	$ 742.02
Ratchets	17	93.24
Pocket Tapes, Repairs and Renewals		98.20
Level, Range and Stadia Rods	44	288.80
Transit and Level Repairs and Renewals		279.79
Stocks, Dies, Taps and Screw Plates		494.62
Melting Pots	19	74.39
Melting Ladles	18	6.85
Torches	73	169.24
Forges	18	110.00
Screw Drivers	7	.86
Graphite	377 lbs.	63.93
Welding Compound	1,000 lbs.	58.90
Borax	2,000 lbs.	78.30
Resin	1,164 lbs.	31.78
Emery Dust, Paper and Cloth		409.19
Sand Paper	28 reams	95.63
Trowels and Hawks	30¼ doz.	257.91
Lines (Plumb and Chalk)	504 doz.	184.80
Ladders	5	14.00
Cap Crimpers	84	28.35
Tar Kettles	2	21.50
Solder and Supplies		449.25
Lumber Crayon and Carpenter Chalk	24 doz.	13.03
Forks (Pitch, Manure and Stones)	10 1-6 doz.	118.57
Saws (Hand)	464	340.90
Cut Off Saw (Towsley "Swing")	1	92.50
Sledges	77	43.28
Shears (Tinners, Snips, etc.)	97	81.36
Drill Sockets	6	3.00
Brass and Bronze	2,305⅜ lbs.	538.42
Rakes (Hand)	42	20.00
Branding Irons	2	2.50
Mica	10 lbs.	35.00
Planes	14	20.40
Hand Bellows	14	14.84
Adzes	2½ doz.	27.65

ITEMS.	UNIT	AMOUNT
Tire Benders	1	18.50
Blocks (Rope and Tackle)	85	91.69
Blocks (Chain Hoist)	9	331.50
Chain Block Repairs and Renewals		7.60
Hose Expanders	1	25.00
Tube Expander	1	2.50
Hot Water Meter	1	160.00
Stillson Wrench Repairs and Renewals		49.81
Horse Shoeing Stock	1	97.00
Machine for Bending Rods for Syphon	1	65.00
Hydraulic Ball Bearing "Giant"	1	70.00
Thermometers	52	52.99
Rock Dryer	1	2,656.00
Miscellaneous Tools and Renewals		444.98
Total		$ 52,817.42

CLASS "B"

Machinery, Renewals and Repairs.

Tube Mills	2	$ 2,560.00
Gas Engines	9	3,955.00
Gas Engine Repairs and Renewals		1,218.27
Well Digging Machine	1	27.25
Well Digging Machine Repairs and Renewals		186.40
Fifth Wheel Platform Truck	3	120.00
Truck Wheels and Axles		15.00
Car Movers	1	3.55
Rock Drills	62	8,322.45
Rock Drill Repairs and Renewals		31,522.18
Oilers, Oil Cans, Funnels and Measures	91⅝ doz	113.95
Utility Measures	22 doz.	30.13
Oil and Grease Cups	1,624	344.52
Scrapers	118	1,294.40
Scraper Repairs and Renewals		885.37
Plows	12	544.45
Plow Repairs and Renewals		380.25
Chain	2,706 lbs.	112.12
Injectors	1	7.00
Injector Repairs and Renewals		15.00
Machine Shop Renewals		256.43
Air Compressors	3	1,163.95
Air Compressor Repairs and Renewals		510.72
Drill Sharpener (Air Hammer)	1	650.00
Drill Sharpener Repairs and Renewals		1,515.95
Pulleys	271	2,130.15
Riveter (Long Stroke)	1	46.00
Hand Crabs	1	52.25
Ball Mill	1	3,260.00
Ball Mill Repairs and Renewals		10,428.06
Mixers (Concrete)	26	21,810.00

ITEMS.	UNIT	AMOUNT
Mixer Repairs and Renewals		3,078.32
Pumps	36	5,957.03
Pump Repairs and Renewals		1,032.02
Shafting	57,744½ lbs.	1,863.67
Shafting Hangers, Boxes, Collars, Couplings, etc.		1,229.02
Gaskets	453⅙ doz.	456.89
Hydraulic Turbine Driver (Exciter Unit)	1	1,841.00
Locomotive (Steam) Repairs and Renewals		777.44
Cocks (Stop, Outlet, etc.)	966	602.45
Dredge Fittings, etc.		5,981.68
Steel Hull and Ladders for Dredge		4,392.80
Steam Shovel Repairs and Renewals		4,809.86
Electric Shovel Repairs and Renewals		377.71
Steam Engine Repairs and Renewals		492.26
Flanges	111	134.76
Water Wheel Repairs and Renewals		745.40
Pipe Threading Machine	1	45.00
Oil Burners	11	219.60
Oil Burner Repairs and Renewals		7.40
Oil Systems (Wilgus)	3	382.50
Oil Meters	2	152.00
Gages and Fittings		100.62
Lathes	3	1,637.75
Lathe Repairs and Renewals		54.48
Drill Presses (Power)	5	310.45
Drill Press Repairs and Renewals		4.00
Emery Wheel and Grinders	66	308.64
Band Saws	11	362.65
Circular Saws	12	90.24
Mower Repairs and Renewals		3.45
Hay Rake Repairs and Renewals		4.60
Whistles	2	2.38
Sprocket Wheels	256	1,206.95
Chain Links	1,848	39.24
Elevators	5	1,164.95
Elevator Repairs and Renewals		3,710.25
Cement Plant, Repairs and Renewals		19,784.54
Rock Crushers	11	5,930.00
Rock Crusher Repairs and Renewals		2,071.52
Pinions, Gears, etc.	90	751.95
Traction Engines)	10)	
Wagons for Same)	26)	52,710.00
Traction Engine Repairs and Renewals		17,833.38
Combined Punch and Shears Repairs and Renewals		28.60
Tire Upsetters, Shrinkers, etc.	4	157.45
Boiler Repairs and Renewals		558.93
Heaters	3	559.00
Friction Hoist	8	1,014.70
Friction Hoist Repairs and Renewals		132.00

ITEMS.	UNIT	AMOUNT
Cars (Tunnel)	60	14,552.00
Cars (Tunnel) Repairs and Renewals		1,053.84
Car Wheels and Repairs		6,946.54
Car Axles	428	1,180.44
Reeves Speeder Repairs and Renewals		177.53
Water Jacket Kiln Feed	1	92.00
Testing Gage (for Water and Steam Gage)	1	171.25
Fluor-spar (for Cement Plant)	30 tons	420.00
Miscellaneous Machine Repairs and Renewals		21.02
Total		$ 263,206.95

CLASS "C"

Construction Material and Supplies.

Lumber	2,971,628 ft.	$ 51,639.03
Lumber (for Concrete Forms)	72,608 ft.	1,309.34
Steel Channel Ribs for Concrete Forms	230 sets	2,342.00
Windows, Doors and Sash		1,363.54
Ties	27,501	3,256.87
Lath	13,000	33.75
Shingles	232,900	622.00
Wedges	387,454	2,750.42
Sash and Door Fittings		126.44
Iron—Angle	9,477 lbs.	275.86
Iron—Common, Strap, Round, Norway, etc.	177,228 lbs.	4,203.82
Iron—Sheet	134,923 lbs.	5,026.15
Iron—Corrugated (Galvanized)	222,524½ sq. ft.	9,370.74
Soft Steel	51,532 lbs.	1,227.04
Hoop Steel	38,940 lbs.	1,849.71
Twisted Steel Bars (for Reinforcing)	3,207,201 lbs.	41,467.61
Round Steel Bars (for Reinforcing)	739,926 lbs.	10,299.61
Screws—Cap, Set, Machine	36,639	401.16
Screws—Lag	12,993	199.35
Screws—Wood	7,158 doz.	93.93
Valves—Gate, Globe, Angle, Check, etc.		1,979.72
Bolts (Various)	222,978	3,704.23
Track Spikes	62,026 lbs.	1,906.23
Track Bolts	5,407 lbs.	303.10
Cotters and Pins	13,824	24.11
Rivets and Burrs	6,537 lbs.	318.87
Washers	15,778 lbs.	484.32
Nuts	6,591½-lbs.	399.33
Blasting Powder and Explosives	1,457,250 lbs.	146,334.77
Fuzees (Insulated)	9,950	399.90
Fuse	635 cases	15,397.26
Caps	487,000	3,683.00
Cap Protectors	7,000	51.40
Delay-Action Exploders	2,000	189.00
Fire Brick	28,500	1,008.90
Fire Brick Blocks	7,140	895.00

[illegible]	[illegible]	[illegible]
Fire Clay	[illegible] lbs.	[illegible]
Fire Clay Brick	[illegible]	[illegible]
Fire Clay Brick and Tile	[illegible]	[illegible]
Rope—Manila	[illegible] lbs.	[illegible]
Rope—Steel	[illegible] ft.	[illegible]
Cable (Steel Wire)	[illegible] ft.	[illegible]
Cable and Steel Wire Fittings		[illegible]
Blocks (small)	[illegible]	[illegible]
Blocks (large)	[illegible]	[illegible]
Hasps	[illegible]	[illegible]
Drawer and Door Pulls	[illegible]	[illegible]
Staples	325 lbs.	[illegible]
Hooks and Eyes	6 doz.	[illegible]
Nails	[illegible] lbs.	[illegible]
Watering Troughs	[illegible]	[illegible]
Turn Buckles	52	[illegible]
Paint (Dry)	2,596 lbs.	[illegible]
Paint (Mixed)	[illegible] gal.	[illegible]
Linseed Oil	[illegible] gal.	[illegible]
Paint and Whitewash Brushes	888	[illegible]
Poles	455	[illegible]
Wire (Feet)	265,441 ft.	[illegible]
Wire (Pounds)	83,780 13-16 lbs.	[illegible]
Asbestos—Gasket Cover, etc.		[illegible]
Lanterns	**53 1-12 doz.**	**[illegible]**
Lanterns, Globes, Wicks, etc.		[illegible]
Putty and Glass		[illegible]
Asphaltum	33 bbls.	[illegible]
Tanks—Water, Air and Oil	**43**	**$ [illegible]**
Rubber and Steam Hose, and Fittings		[illegible]
Pails and Buckets	89 11-12 doz.	[illegible]
Roofing and Building Paper	648 rolls	[illegible]
Waterproof Paper	80,960 ft.	[illegible]
Tar Paper	150,000 ft.	[illegible]
Hinges	730	[illegible]
Tents and Flys	**354**	**[illegible]**
Stretchers, Fittings and Renewals		[illegible]
Candles	3,033 boxes	[illegible]
Sheet Tin	401 sheets	[illegible]
Sheet Lead	106 lbs.	[illegible]
Sheet Copper	1,155 3-16 lbs.	[illegible]
Smelter and Pig Lead	200 lbs.	[illegible]
Babbitt	9,666 lbs.	[illegible]
Gypsum	3,371 713 tons	[illegible]
Cement	155,021 bbls.	[illegible]
Sacks (Cement and Gypsum)	56,104	[illegible]
Sacks (Sugar)	5,000	[illegible]
Oakum and Calking Lead	202 lbs.	[illegible]
Paper Bags	17,200	[illegible]
Cement Covers	**332**	**[illegible]**

ITEMS.	UNIT	AMOUNT
Barrels (Water and Oil)	156	380.90
Drums (for Oil)	54	345.32
Sewer Tile	3,452½ ft.	273.44
Terra Cotta Pipe	240 ft.	74.61
Terra Cotta Pipe Fittings		47.02
Tar	10 bbls.	60.00
Rails	381.492 tons	9,795.99
Fish Plates and Bolts	5,201 prs.	1,045.57
Rail Fittings		577.50
Rail Bonds	2,750	1,149.00
Rail Bond Compressor	1	22.50
Split Switch and Frog with Extras		275.14
Concrete Carts	91	1,658.25
Concrete Cart Repairs and Renewals		316.19
Glue Pots and Glue		52.88
Window Fastenings		6.75
Locks, Padlocks, Keys and Sets	1,015	419.70
Butts and Thimbles	439	22.98
"Jumbo" Irons (for Concrete)	4 sets	193.90
Wire Cloth Netting and Screen	9,909 sq. ft.	558.12
Wire Fabric	663,015 sq. ft.	3,228.91
Pipe	272,896½ ft.	22,739.42
Pipe Fittings		1,649.80
Casings and Fittings		4,984.83
Cross Arms	420	146.35
Cross Arm Pins	1,750	28.98
Fire Extinguishers	26	82.00
Tunnel Forms	114	946.00
Tunnel Form Steel Ribs	261	1,846.00
Hard Rubber and Vulcan Fibre		.66
Dowel Pins	6,910	81.92
Pebbles	434.1260 tons	1,589.51
Pebble Screens	20	348.50
Sacks for Pebbles	7,000	274.25
Brads	21 lbs.	1.26
Barbed Wire	6,214 lbs.	187.99
Channel Iron	3,350 lbs.	105.19
"I" Beams	163	1,410.25
Lime (Unslaked)	729 bbls.	898.45
Tramway Repairs and Renewals		5,085.87
Manhole Covers, Rings and Steps		244.20
Soft Soap (for Concrete Forms)	15,786 lbs.	278.42
Wood Fibre	142½ lbs.	48.45
Concrete Covering	15,000 lbs.	150.00
Conduit Forms	78	1,749.50
Needles and Twine	12,114¾ lbs.	1,199.61
Steel Push Brooms	6 doz.	29.80
Tufa Mill Extras (at Haiwee)		299.61
Sluicing Material (for Haiwee Dam)		5,964.99
Spillways Material		1,277.00

ITEMS.	UNIT	AMOUNT
Structural Steel Covering (for Clinker Storage)		2,150.00
Hydraulic Sluice Gates and Frames (Mojave)	12	1,296.00
Ball Mill Bin	1	742.00
Steel Syphons for Dove Springs and San Antonio	2	22,315.00
Sand and Gravel	1,854 cu. yds.	927.00
Sand Rolls	1 set	495.00
Sand Roll Repairs and Renewals		105.25
Miscellaneous Hardware		726.26
Total		$ 740,511.93

CLASS "D"

Electrical Equipment and Supplies.

Transformers	108	$ 22,116.67
Ammeters	7	220.96
Wattmeters	22	1,770.15
Wattmeter Repairs and Renewals		4.96
Volt-Amp.-Meters	14	61.46
Volt Choke Coils	30	172.50
Volt Meters	10	400.73
Motors	72	16,673.00
Motor Repairs and Renewals		2,429.25
Electrical Supplies		4,183.09
Indicating Cartridge Fuses	12	1.08
Rubber Bushings	110	27.50
Receptacles (Potential)	57	15.10
Receptacles (Weatherproof)	650	114.99
Return Bends	36	1.61
Telephone Fittings and Renewals		608.37
Telephone Exchange Renewals		21.56
Wiring Cord	19,926 ft.	284.72
Friction Tape	1,677 lbs.	585.95
Insulating Tubing	292	10.04
Insulators	10,454	622.35
Electric Lamps, Globes, Shades, etc.		4,962.31
Test Sets	22	553.90
Switch Boards	1	55.00
Switch Board Repairs and Renewals		69.50
Switches and Fittings		1,810.67
Dynamo (or Generator)	1	550.00
Dynamo (or Generator) Repairs and Renewals		247.96
Carbons	5,800	138.45
Wire Moulding and Caps	250 ft.	4.50
Electric Locomotives	4	6,380.00
Electric Locomotive Repairs and Renewals		797.67
Electric Hoist	1	825.00
Electric Hoist Repairs and Renewals		6.35
Transformer House Frame (Steel)		57.50
Transformer Float	1	300.00
Auto Starter Repairs and Renewals		207.76

ITEMS.	UNIT	AMOUNT
Sash Cord	844 lbs.	220.80
Power Plant		169.55
Trolley Hangers	550	126.25
Trolley Wheels	94	489.54
Trolley Material		410.63
Porcelain Fuse Boxes	50	20.70
Electric Tool, Post Grinder	1	45.35
Circuit Breakers	16	547.70
Total		**$ 69,323.03**

CLASS "E"

Oil, Waste, Etc.

Lubricating Oils	842.9 bbls.	$ 12,784.02
Fuel and Illuminating Oils	141,034.68 bbls	109,709.18
Grease (Lubricating)	97,462 lbs.	6,436.55
Distillate	211,342½ gals.	17,048.05
Packing	5,456½ lbs.	1,868.29
Waste	23,979 lbs.	1,836.94
Oil Filters	1	76.50
Oil Containers	7	42.00
Total		**$149,801.53**

CLASS "F"

Office Equipment and Furnishings.

Office Furnishings		$ 2,315.64
Office Desks and Chairs	9	249.70
Mimeograph	1	50.00
Adding Machines	3	405.00
Boxes (Empty)	50½ doz.	37.90
Wrapping Paper and Cutter	892 lbs.	44.60
Stationery		5,469.48
Telephone Moving		1.00
Marking Pots	2	.65
Stencils		2.58
Inks and Brushes		137.55
Lamps and Chimneys		226.92
Stools and Chairs (Office and Drafting)	56	170.35
Watches and Clocks	5	26.00
Typewriters	6	483.85
Typewriter Repairs and Renewals		148.53
Numbering Machines	5	61.35
Bags (Leather)	25	44.90
Bags (Mail), Canvas	14	46.80
Total		$ 9,922.80

CLASS "G"

Transportation Equipment and Supplies.

ITEMS.	UNIT	AMOUNT
Automobiles	3	$ 5,119.80
Automobile Repairs and Renewals		5,979.01
Motorcycles	1	265.00
Motorcycle Repairs and Renewals		135.58
Whips, Cushions, etc.	386	408.75
Saddles, Bridles, etc.	17	230.55
Brushes and Curry Combs	6 doz.	30.00
Wagons and Carts	83	6,871.65
Wagon and Cart Repairs and Renewals		2,450.00
Feed Bags	6	27.00
Saddle and Nose Bags	10	17.27
Toe Calk and Calk Steel	2,949 lbs.	138.50
Mule and Horse Shoes and Nails		1,519.61
Lumber (Wagon Repairs)	3,116 ft.	336.03
Blankets and Oil Covers	67	195.25
Harness Repairs and Renewals		5,055.36
Horses	43	5,500.00
Mules	6	975.00
Buggies and Carriages	3	274.00
Buggy and Carriage Repairs and Renewals		135.55
Rentals (Live Stock)		35,466.88
Live Stock Inspection		729.75
Total		$ 71,860.54

CLASS "H"

Cook and Bunk House Equipment.

Cook House, Commissary, etc.		$ 27,562.67
Cots	640	1,921.75
Hay	2,960.1682 tons	29,960.97
Salt (Rock)	3,701 lbs.	22.05
Grain	5,420.197 lbs.	71,358.53
Coal and Screenings	1,655.414 tons	19,223.66
Coke	70,625 lbs.	469.56
Stoves, Pipe and Fittings		1,901.07
Sinks, W. Closets, Boilers, Tubs, etc.		275.46
Camp Chairs	144	91.50
Wash Bowls and Basins	48	71.40
Water Bags and Canteens	134 doz.	1,032.44
Folding Tables	22	49.50
Bunk House Equipment		1,482.48
Water Jars ("Ollas")	19	18.50
Scales	24	374.17
Total		$155,815.71

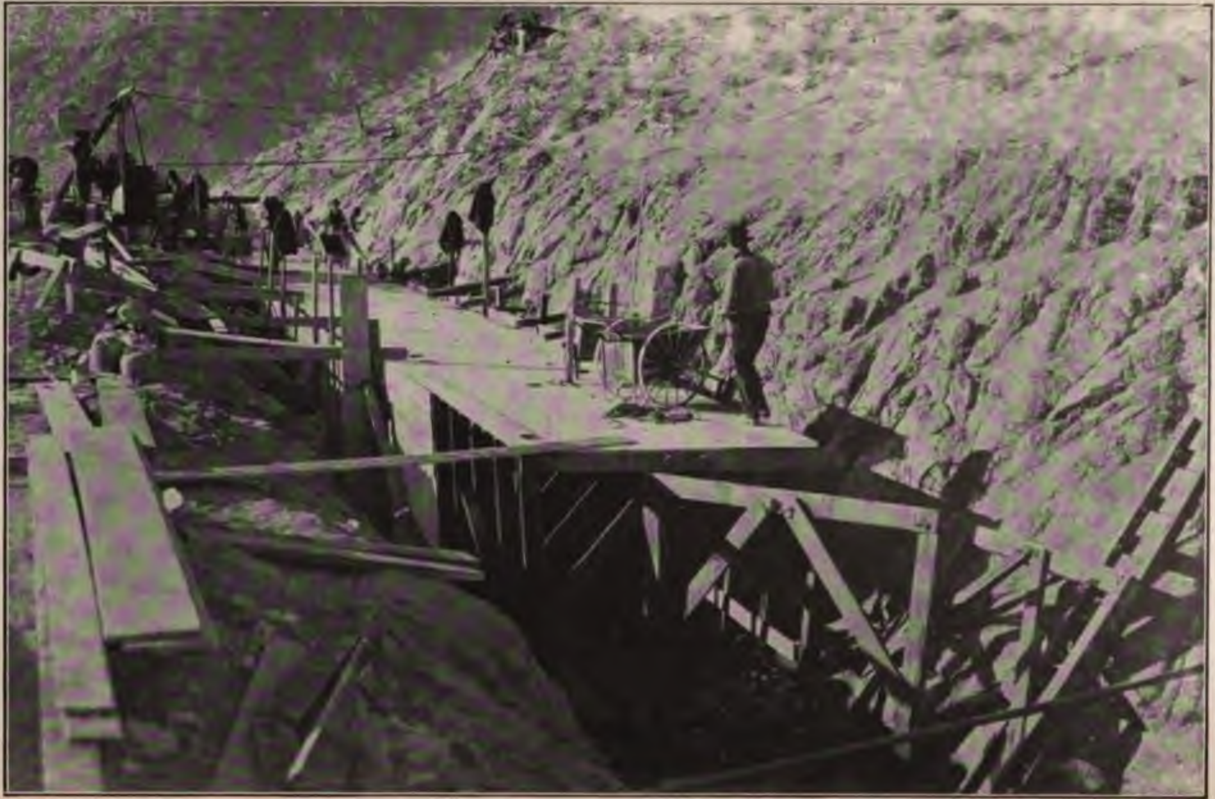
CLASS "I"

Miscellaneous.

ITEMS.	UNIT	AMOUNT
Printing		$ 6,027.81
Expenses		5,824.72
Fencing (for Fencing Land)	200 rods	50.25
Tarpaulins (Hay Covers)	23	263.54
Horse Medicine		212.82
Drugs and Medicines		804.44
Trees (Fruit and Shade)	48	17.95
Cloth	44 bolts	189.61
Books, Maps and Signs		149.50
Rubber Boots and Slickers	274 prs.	1,003.46
Cartage		394.65
Laboratory Supplies		1,236.82
Recording Fees		1.90
Rentals (Miscellaneous)		2,328.50
Certificate of Title	5	295.00
Transportation Charges		5,165.14
Express Charges		1,421.45
Labor		485.76
Duck (Cloth)	595¾ yds.	160.72
Advertising		49.17
Telephone Service		979.80
Telegraph Service		966.27
Blacksmith Work		497.20
Towel Service		217.85
Water Supply Investigation		90.50
Water Supply		193.65
Photographs		129.71
Evaporation Tanks	2	60.00
Surveyor—Lumber	22,000 ft.	95.00
Miscellaneous Merchandise		6,185.67
Excavation		14,545.86
Coffins	12	47.00
Total		$ 50,091.72

RECAPITULATION.

Class "A"—Tools, Carpenter, Blacksmith, etc.	$ 52,817.42
Class "B"—Machinery, Renewals and Repairs	263,206.95
Class "C"—Construction Material and Supplies	740,511.93
Class "D"—Electrical Equipment and Supplies	69,323.03
Class "E"—Oil, Waste, etc.	149,801.53
Class "F"—Office Equipment and Furnishings	9,922.80
Class "G"—Transportation Equipment and Supplies	71,860.54
Class "H"—Cook and Bunk House Equipment	155,815.71
Class "I"—Miscellaneous	50,091.72
GRAND TOTAL	$1,563,351.63



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Annual Report of Accounting Dept.

LOS ANGELES AQUEDUCT

FIFTH ANNUAL REPORT

FOR THE FISCAL YEAR ENDING JUNE 30, 1910.

To the Honorable Board of Public Works,

Gentlemen: This Department herewith transmits to you its Fifth Annual Report for the fiscal year ending June 30, 1910.

Attention is invited to the Third and Fourth Annual Reports, in which the accounts appear in detail with explanations as to their use. With a few minor changes, titles of the accounts are the same; where new accounts appear the name of the account is self-explanatory. Therefore it is deemed unnecessary to enter into any further analysis of the accounts in this Report, which are submitted in concrete form.

By reason of the remote and inaccessible locality in which much of the work is being prosecuted, it is not possible to obtain and assemble the data necessary to admit the closing of the accounts until the 15th of the month. Therefore, this Report only contemplates the total receipts and disbursements to the close of May, 1910.

Respectfully submitted,

E. V. HARDING,
Chief Accounting Officer.

CASH TRANSACTIONS FOR FISCAL YEAR ENDING JUNE 30, 1910.

Cash on hand, July 1, 1909		$2,077,547.87	

Receipts.

Bills Collectible	$ 105,434.88		
Sale of Bonds	5,262,180.00		
Total Receipts		$5,367,614.88	
Total Receipts and Cash on Hand			$7,445,162.75

Disbursements.

Pay Rolls	$3,562,776.45		
Material, Supplies and Equipment	1,879,005.26		
Services and Misc. Expense	327,769.12		
Freight and Express	549,659.49		
Construction Contracts	214,772.93		
R. of W., Land and Water Rights	73,947.21		
Discounts Refunded	370.11		
Taxes	14,292.08		
Total Disbursements		$6,622,592.65	
Cash on Hand, June 30, 1910		822,570.10	
Total Disbursements and Cash on Hand			$7,445,162.75

STATEMENT OF FLOATING LIABILITIES AS OF JUNE 30, 1910.

Outstanding Purchase Bills and Contracts	$230,360.46
Outstanding Vouchers	126,077.24
Unpaid Wages	142,604.60
Total	$499,042.30

CONSOLIDATED BALANCE SHEET OF THE GENERAL LEDGER AS OF MAY 31, 1910.

Assets.

Bonds authorized sold but not delivered	$ 9,794,400.00
Cash on hand in City Treasury and Bank	1,321,391.95
Los Angeles Aqueduct General Expenses	411,276.34
Los Angeles Aqueduct Equipment Expenses	1,381,762.02
Los Angeles Aqueduct Construction Expenses	11,553,654.88
Accounts Collectible	90,097.89
Materials and Supplies on hand	595,367.42
Water Investigation	28,252.96
Total	$25,176,203.46

Liabilities.

Bonds authorized	$24,500,000.00
Premium on Bonds sold	60,766.33
Vouchers unpaid	213,614.69
Pay Roll items unpaid	282,969.16
Discount on Purchase Bills	21,926.92
Rental Earnings	10,666.96
Deferred Payments on Contracted Materials and Supplies	86,259.40
Total	$25,176,203.46

DETAIL OF EXPENDITURES AS EVIDENCED BY THE CONSOLIDATED BALANCE SHEET OF GENERAL LEDGER

(As of May 31, 1910.)

GENERAL EXPENSE ACCOUNTS.

Salaries of General Officers	$ 74,006.83
Salaries of Clerks and Attendants	145,617.92
General Office Expenses and Supplies	74,532.63
General Office Furniture and Fixtures	2,365.27
Stationery and Printing	26,654.18
Legal Expenses	35,235.88
Insurance	1,146.31
Taxes	36,217.87
Interest and Discount	1,080.00
Other Expenses	14,419.45
Total	$411,276.34

EQUIPMENT EXPENSE ACCOUNTS.

Miscellaneous Construction Equipment	$ 820,297.19
Live Stock	119,826.06
Automobiles and Motorcycles	18,660.17
Traction Engines	100,709.57
Dredgers	46,575.60
Miscellaneous Vehicles	35,341.63
Surveying and Drafting Instruments	3,617.32
Well Drilling Machinery	8,152.21
Miscellaneous Camp Equipment	44,543.27
*Suspense Equipment	184,039.00
Total	$1,381,762.02

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*These Suspense items will eventually be charged to the different Expense Equipment Accounts when the necessary data to do so is obtained by the Accounting Department.

CONSTRUCTION EXPENSE ACCOUNTS.

Engineering	$ 318,247.89
Real Estate, Water Rights and Right of Way	1,648,233.08
Water Supply	231,493.75
Telegraph and Telephone Lines	66,694.23
Roads and Trails	202,551.90
Electric Power Plants	162,565.37
Power Lines	185,829.85
Cement Plant	507,155.86
Railroads	4,824.25
Miscellaneous Structures and Furnishings	226,498.11
Tufa Plants	52,892.55
Canals	159,762.95
Tunnels	3,667,016.02
Syphons	39,060.41
Conduits	1,894,861.35
Flumes	21,769.08
Reservoirs	44,095.26
Crossings	2,228.03
Field Administration Expense	275,633.21

Other Expenses		50,048.94
Low Tension Branch Power Lines		21,393.23
*Accounts held in Suspense:		
Passenger Transportation	$ 12,142.08	
Telephone Service	21,459.62	
Freight Transportation	1,170,253.25	
Water Service	49,361.70	
Automobile Service	17,710.24	
Material and Supplies	478,390.58	
Unadjusted	21,482.09	
		1,770,799.56
Total		$11,553,654.88

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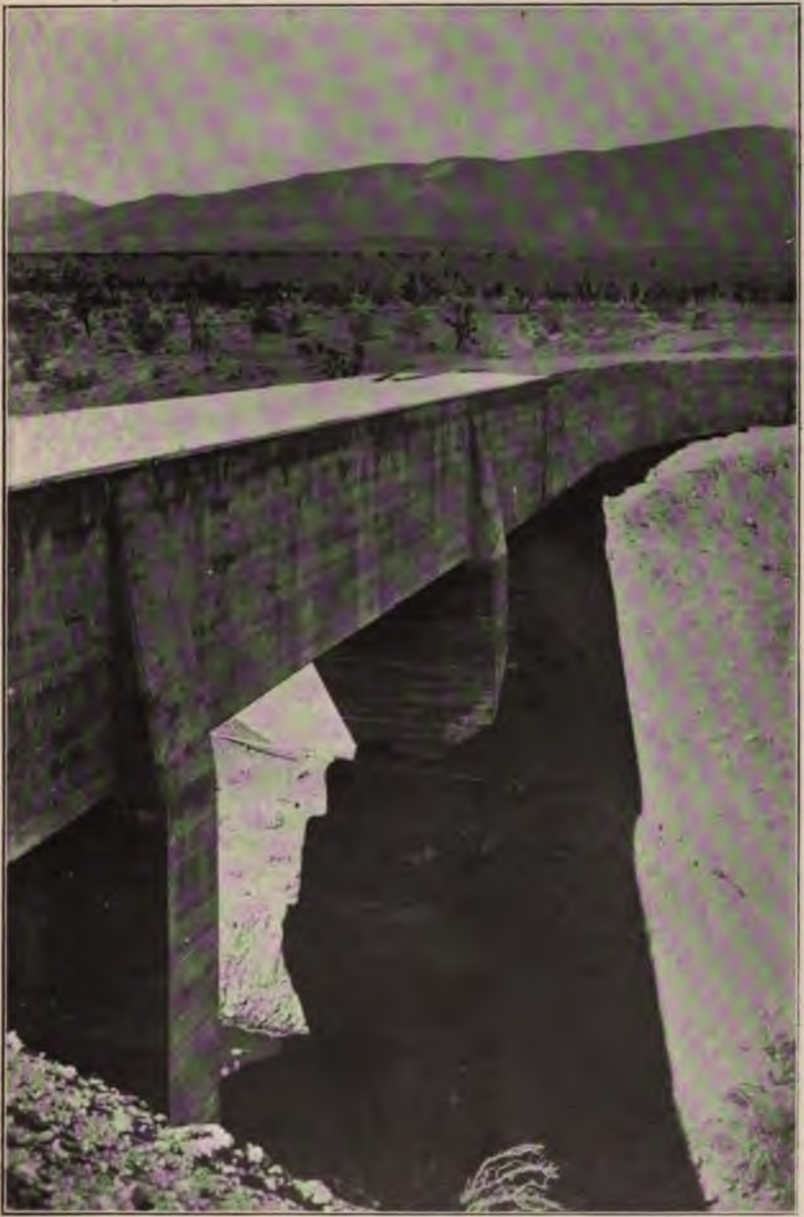
*These Suspense items will eventually be charged to the different Construction Expense Accounts benefited when the necessary data to do so is obtained by the Accounting Department.

E. V. HARDING,
Chief Accounting Officer.



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Report of the Legal Department

LOS ANGELES AQUEDUCT

June 30, 1910.

To the Honorable Board of Public Works
of the City of Los Angeles.

Gentlemen: I beg to submit the following report of work done by the Legal Department of the Aqueduct Bureau since my last report, to-wit: June 30, 1909.

Very respectfully,
W. B. MATHEWS.

CONTRACTS.

The following is a complete list of the contracts prepared by the Legal Department of the Bureau of the Los Angeles Aqueduct, for machinery, equipment, materials, supplies and services, since the date of the last Annual Report, June 30, 1909, including contracts founded on specifications approved by the Board of Public Works and awards made after advertisement, and contracts made without advertisement, under the emergency provisions of the City Charter:

A. CONTRACTS MADE AFTER ADVERTISING FOR BIDS.

Spec. No.	Contractor.	Date.	Subject.	Amount.
75	Westinghouse Elec. & Mfg. Co.	7-16-09	Locomotives and Repair Parts	$ 3,447.17
76	Allis-Chalmers Company	7-23-09	Ball and Tube Mills	5,820.00
77	Allis-Chalmers Company	7-16-09	Motors, Transformers and Circuit Breakers	1,745.00
78	Smith-Booth-Usher Co.	7-14-09	Air Drills	712.20
79	Municipal Engineering & Contracting Co.	7-28-09	Concrete Mixers	6,550.00
79	Fairbanks-Morse & Co.	7-24-09	Concrete Mixers	3,625.00
80	Harper & Reynolds Co.	8-19-09	Water Hose	930.00
81	Westinghouse Elec. & Mfg. Co.	8-24-09	Transformers	2,325.00
83	Westinghouse Elec. & Mfg. Co.	9- 3-09	Induction Motors	2,703.60
84	Llewellyn Iron Works	7-26-09	Car Axles	115.00
84	Keystone Iron Works	7-27-09	Car Wheels and Wheel Caps	277.00
85	Western Pipe & Steel Co.	8- 7-09	Oil Storage Tank	1,985.00
86	Baker Iron Works	8-26-09	Air Compressors	722.00
87	Lacy Mfg. Co.	8-23-09	Hull for Dredge	2,464.00
88	Ames Harris Neville Co.	8-26-09	Cement Sacks	5,375.00
89	Fairbanks-Morse & Co.	9- 8-09	Concrete Mixer	975.00

Spec. No.	Contractor.	Date.	Subject.	Amount.
90	Adams & Wright	9-10-09	Gypsum	3,600.00
91	Los Angeles Hay Storage Co.	9-18-09	Oat Hay	1,650.00
91	E. H. Loveland	9-18-09	Hay	24,080.00
92	Oakdale Milling Co.	9-16-09	Rolled Barley	28,800.00
93	Fulton Engine Works	9-17-09	Electric Hoist	825.00
94	San Fernando Rock Co.	9-27-09	Sand and Gravel	750.00
95	Pacific Coast Mfg. Co.	9-25-09	Engine Lathe	750.00
96	John H. Brown	10- 4-09	Armored Water Hose	195.00
96	Pacific Coast Mfg. Co.	10-11-09	Armored Air Hose	240.00
97	Chris Eccles, Manager	10- 4-09	Incandescent Lamps	1,400.00
98	Baker Iron Works	10-19-09	Feed Water Heater	489.00
99	Petrolithic Pavement Co.	10-21-09	Rock Crushers	1,554.00
99	E. P. Bosbyshell Co.	10-21-09	Rock Crushers	2,055.00
100	McCan Mechanical Works	10-21-09	Ladder for Dredge	978.80
101	California Hardware Co.	11-13-09	Round Steel Bars—From $1.49 to $1.74 per 100 lbs.	
102	Union Hardware & Metal Co.	10-27-09	Round Steel Bars—$1.36¼ per 100 lbs.	
103	Llewellyn Iron Works	11- 4-09	Tunnel Car Axles and Car Wheel Caps	$ 148.00
103	Keystone Iron Works	11- 6-09	Tunnel Car Wheels	402.00
104	Wm. H. Hoegee Co.	11- 6-09	Tents and Flies	4,435.00
105	Byron-Jackson Iron Wks.	11-17-09	Centrifugal Pump and Motor	1,282.00
106	Fairbanks-Morse & Co.	11-26-09	Gas Engines	780.00
106	Bailie & Brandt Co.	11-27-09	Gas Engines	500.00
107	Venator & Davis	12- 1-09	Meat for Cement Mill Camp, for the period of six months from December 10, 1909, at the following prices per 100 lbs.: Beef, $7.50; Sheep Mutton, $11; Pork, $12; Goat Mutton, $9.50.	
108	Newell Mathews Co.	12- 1-09	Wagons and Wagon Gears	1,324.25
109	Haas-Baruch & Co.	1-10-10	Commissary Supplies—Approximately	4,587.75
109	Weyl-Zuckerman & Co.	1-10-10	Commissary Supplies—Approximately	870.85
109	Frank Simpson Fruit Co.	1-11-10	Commissary Supplies—Approximately	268.37
109	Capitol Milling Co.	1-10-10	Commissary Supplies—Approximately	1,326.97
109	Geo. H. Stoll & Co.	1-11-10	Commissary Supplies—Approximately	946.70
109	Richert Brothers	1-10-10	Commissary Supplies—Approximately	28.33
109	Newmark Brothers	1-12-10	Commissary Supplies—Approximately	126.80
111	Westinghouse Elec. & Mfg. Co.	12-27-09	Transformers	4,000.00
112	Lacy Mfg. Co.	1- 3-10	Dove Springs and San Antonio Syphons	22,315.00
113	General Electric Co.	12-16-09	Induction Motor	707.00
114	Union Oil Co. of Cal.	12-15-09	All engine distillate required for period of six months from date of contract at following prices per gallon: 8c in carload lots and 8½c in less than carload lots.	

Spec. No.	Contractor.	Date.	Subject.	Amount.
115	**Fairbanks-Morse & Co.**	1- 4-10	Generator	550.00
116	Greer-Robbins Co.	12-20-09	Automobile	1,876.25
119	E. K. Wood Lumber Co.	1-29-10	All lumber required for one year from date of the contract — Approximately	$14,398.25
120	J. A. Hill	1-20-10	Hauling of freight—28c and 30c per ton mile.	
121	Harper & Reynolds Co.	2- 3-10	Shovels	3,349.00
122	Greer-Robbins Co.	2- 4-10	Automobile	1,387.30
123	Oakdale Milling Co.	2-10-10	Rolled Barley	16,500.00
124	D. C. McCan	2- 1-10	Ladder for Dredge	950.00
125	Union Hardware & Metal Co.	2- 7-10	Re-enforcing Bars—$2.55 and $2.70 per 100 lbs.	
126	Los Angeles Pressed Brick Co.	3-11-10	Fire Clay Blocks	2,010.00
127	Fulton Engine Works	3-12-10	Rock Dryer	2,656.00
128	Pacific Coast Mfg. Co.	2-16-10	Repair parts for drills and drill sharpeners—Approx.	4,100.00
130	Eccles & Smith Co.	3- 8-10	Incandescent Lamps	687.50
131	Krogh Mfg. Co.	3-19-10	Horizontal Turbine Pump	570.00
132	Baker Iron Works	3-26-10	Spillway Gate Stands and Shafts	899.00
134	Greer-Robbins Co.	3-24-10	Automobile	1,876.25
135	Trenton Iron Co.	4-19-10	Material for Aerial Tramway	4,120.00
136	Pacific Coast Mfg. Co.	4- 2-10	Drilling Equipment	10,786.25
137	Wm. H. Hoegee Co.	3-31-10	Tents and Flies	4,295.00
138	J. A. Hill	4- 9-10	Transportation of Sand and Gravel—79c per cu. yd.	
139	Westinghouse Elec. & Mfg. Co.	4- 9-10	Electric Mine Locomotives	3,380.00
140	B. F. Kierulff, Jr. & Co.	4-19-10	Wire—Approximately	6,249.64
141	Atkins, Kroll & Co.	5- 5-10	Silex Blocks—Approximately	1,892.75
142	International High Speed Steel Co.	4-13-10	Drill Steel—Approximately	2,750.00
143	Bailie & Brandt Co.	4-29-10	Gas Engine	725.00
144	Allis-Chalmers Co.	5- 6-10	Motors	8,967.00
144	Wagner Electric Mfg. Co.	4-28-10	Motors	558.37
145	Llewellyn Iron Works	5- 3-10	Material for Steel Frame Buildings	6,500.00
146	Keystone Iron Works	5- 3-10	Tunnel Car Wheels	900.00
146	Pacific Clay Working Machine Co.	5- 2-10	Tunnel Car Axles	270.00
149	General Electric Co.	5- 6-10	Motor	776.25
151	Westinghouse Elec. & Mfg. Co.	5-19-10	Transformers	$ 3,450.00
152	United Iron Works	5- 4-10	Sand and Gravel Pump	1,024.00
161	Crane Company	5-31-10	2 30" Gate Valves	602.00
167	United Oil Refineries	6-14-10	All engine distillate required for use of Aqueduct for period of six months from June 15th—7c per gallon.	
172-B	Pacific Hardware & Steel Co.	8- 9-09	Tool Handles	$ 3,468.80
173-B	Allis-Chalmers Co.	7-23-09	Forged Steel Balls	709.00
174-B	Llewellyn Iron Works	7- 2-09	Tunnel Forms	975.00
175-B	H. R. Boynton Co.	7 -7-09	2" Screw Pipe—Approx	4,088.70
176-B	E. H. Loveland	7-12-09	Barley Hay	6,475.00
178-B	H. R. Boynton Co.	7- 7-09	1" Screw Pipe—Approx	1,188.00
179-B	C. A. Bennett	8-21-09	Belting Leather	981.00

Spec. No.	Contractor.	Date.	Subject.	Amount.
179-B	Harper & Reynolds Co.	8-19-09	3" to 9" Rubber Belting—From $0.0965 to $0.6035 per foot.	
180-B	Kellogg & Russell	7-21-09	Barley Hay	5,140.00
182-B	Union Hardware & Metal Co.	8- 7-09	Conveyor Belt	627.00
183-B	Standard Oil Co.	9-22-09	Mining Candles	8,000.00
184-B	Hoffman Hardware Co.	8-24-09	Nails	1,803.50
185-B	Union Hardware & Metal Co., Cal. Hardware Co., and Harper & Reynolds Co.	10- 5-09	Explosives—Approximately	68,525.58
186-B	Crane Company	9-17-09	2" Pipe—Approximately	1,299.60
187-B	Crane Company	9-17-09	4¼" O. D. Casing—Approx.	1,060.20
189-B	Standard Underground Cable Co.	10-19-09	Copper Cable—Approx.	2,632.00
191-B	Baker Iron Works	10-13-09	Structural Steel	2,150.00
192-B	Fulton Engine Works	10-18-09	Steel Plates	602.00
193-B	H. R. Boynton Co.	10-30-09	Sheet Steel—Approx.	517.50
194-B	Baker Iron Works	10-19-09	Structural Steel	630.00
195-B	Western Boiler Works	10-27-09	Steel Conduit Forms	720.00
196-B	Union Hardware & Metal Co.	10-26-09	Hoop Steel—Approx.	1,125.75
197-B	Riverside Mill Co.	11- 3-09	Rolled Barley	2.325.00
198-B	Llewellyn Iron Works	11- 4-09	Tunnel Forms	731.25
200-B	Pacific Coast Mfg. Co.	11-20-09	6" O. D. Casing—Approx.	1,196.10
201-B	Harper & Reynolds Co.	12-10-09	Sheet Steel—Approx.	1,045.92
202-B	Union Oil Co. of Cal.	12- 8-09	Engine Distillate	1,320.00
203-B	California Hardware Co.	12- 7-09	2" Screw Pipe—Approx.	2,103.00
204-B	Lacy Mfg. Co.	12-18-09	Sluicing Trough	1,859.80
205-B	Baker Iron Works	12-18-09	16" Sheet Steel Pipe—Approximately	1,550.00
207-B	Fulton Engine Works	1-15-10	Hydraulic Sluice Gates and Frames	1,296.00
208-B	McKain Mfg. Co.	1-29-10	Screw Conveyors	720.00
209-B	E. G. Judah & Co.	1-24-10	Tar Paper	$ 766.00
210-B	Fulton Engine Works	2-18-10	Ball Mill Bin	742.00
211-B	Harper & Reynolds Co.	2-21-10	Rails, Splice Bars, Bolts and Nuts—Rails, per ton, $28.92; Splice Bars, Bolts and Nuts, per set, 26½c.	
212-B	Adams Pipe Works	2-19-10	2" Screw Pipe—Approx.	1,388.00
214-B	American Steel & Wire Co.	2-21-10	Woven Wire Fabric—Approximately	776.02
215-B	Capito-Blythe-Whitney Co.	3-31-10	Sluicing Trough	3.450.00
216-B	Crane Company	3-11-10	6" and 8" O. D. Casing	1.302.48
217-B	Lacy Mfg. Co.	3-15-10	Riveted Steel Pipe	1,830.00
218-B	Union Hardware & Metal Co.	3-11-10	Sheet Iron—Approx.	411.25
219-B	Phoenix Milling Co.	3-14-10	Rolled Barley	3,990.00
220-B	Harper & Reynolds Co.	3-18-10	Nails	904.25
221-B	Baker Iron Works	3-24-10	18" Riveted Steel Pipe	1,195.00
222-B	John L. Brickels	3-23-10	Ribs for Tunnel Forms	407.00
223-B	Llewellyn Iron Works	3 23-10	Tunnel Cars	1.312.50
225-B	H. R. Boynton Co.	4-14-10	Sheet Iron—Approx.	675.00
226-B	Baker Iron Works	4-19-10	Ribs for Tunnel Forms	339.00
227-B	Western Pipe & Steel Co	5- 6-10	Riveted Steel Pipe	960.00
228-B	Union Hardware & Metal Co.	5-11-10	Conveyor Belt—Approx.	1,404.10
230-B	H. R. Boynton Co.	5-17-10	2" Screw Pipe—Approx.	2,716.00

B. CONTRACTS MADE WITHOUT ADVERTISEMENT FOR BIDS.

Contractor.	Date.	Subject.	Amount.
231-B Western Pipe & Steel Co.	5-24-10	14" Riveted Pipe	1,314.00
Nettleton & Kellerman	7- 3-09	Gravel	$ 40.00
Henshaw-Bulkley & Co.	7- 8-09	Jeffrey Drills	3,255.40
Allis-Chalmers Co.	7-15-09	Modifying contract dated Jan. 9, 1909, for one exciter unit.	
Pacific Coast Manufacturing Co.	7-16-09	Leyner Drills	4,300.80
Edward Lingwood	7-23-09	Gravel	40.00
Vulcan Iron Works	8-26-09	Locomotive	4,400.00
Salome B. de Raggio	9-13-09	Privilege of dumping waste from tunnel	85.00
Marion Steam Shovel Co.	9-21-09	Machinery	3,500.00
Automatic Weighing Machine Company	9-30-09	Weighing and Sacking Machine	600.00
Marion Steam Shovel Co.	10-18-09	Steam Shovels	19,000.00
Marion Steam Shovel Co.	10-18-09	Repairs for Steam Shovels	575.00
Allis-Chalmers Co.	10-26-09	Tube Mill and Friction Clutch Pulley	1,430.00
Southern Pacific Co.	12-15-09	Spur Track at Monolith	1,197.00
A. C. St. John	12-16-09	Hauling 7,000 tons of Clay	7,000.00
Marion Steam Shovel Co.	12-17-09	Steam Shovel	8,675.00
Holt Manufacturing Co.	1- 3-10	Reconstruction of three Traction Engines	3,000.00
Allis-Chalmers Co.	1- 7-10	Tube Mills	3,490.00
Riverside Portland Cement Co.	1-13-10	100,000 Bbls. Cement	145,000.00
Clara Rose Raymond	1-26-10	House Furniture and Lease of certain other furniture	100.00
D. J. Desmond	2-14-10	Re-draft of contract for furnishing meals to employes at all camps, except at the Cement Mill, where City maintains service, changing price from 21 meals for $5, to 25c per meal, straight.	
Webb and Ed. Walker	2-24-10	Water from Olancha Creek —$5.00 per month.	
Clara Raymond and Lavina Zoller	3- 1-10	Rock—5c per ton for all taken after date of contract, and $142 for that previously taken.	
Southern Pacific Co.	4- 8-10	Spur at Soda Springs Canyon	700.00
Fulton Engine Works	4-13-10	Constructing two Gasoline Locomotives	$ 1,800.00
Southern Pacific Co.	5- 3-10	Spur Track at Mojave	460.00
P. B. Engh	5-11-10	Agreement to sell certain concrete mixers belonging to the city.	
Frank Harry Walker	5-20-10	Privilege of camping and dumping waste	450.00
Riverside Portland Cement Co.	5-31-10	Modifying contract dated January 13, 1910, as to deliveries.	

LANDS AND RIGHTS OF WAY.

The following is a complete list of purchases of lands and rights of way for the Aqueduct system, since the date of the last Annual Report, June 30, 1909:

A. LANDS.

NAME OF SELLER.	ACREAGE.
Cuddeback, W. N.	14.9
Hand, Mark P.	560.
Newman, L. M.	240.
Noble, C. F.	40.
Perry, Robt. R.	10.
Plank, C. A.	50.
Williams, Ben T., Estate of	160.

B. RIGHTS OF WAY OVER PRIVATE LANDS.

Flynn, Wilber E.	6.49
Flynn, Wilber E. (Easement)	1.69
Frakes, S. H. (Easement)	00.
Jenkins, W. W., et al.	00.
Jones, J. P. (Easement)	23.83
Walters, Wm. (Easement)	00.

SPECIAL USE PERMITS ISSUED BY THE FOREST SERVICE OF THE UNITED STATES.

LOCATION.	PURPOSE.
Owens Valley	Pipe Line
San Francisquito Canyon	Road
Olancha	Gravel Pit
Olancha	Pipe Line
Olancha	Gravel Pit

PROCEEDINGS IN THE FEDERAL DEPARTMENTS IN WHICH APPEARANCE HAS BEEN MADE IN BEHALF OF THE CITY FOR THE PURPOSES OF A CONTEST, ADJUSTMENT, OR OTHERWISE.

Contest with George Chaffey in re his application for reservoir sites on Cottonwood Creek.

Contest with George Chaffey in re his application for rights of way on Cottonwood Creek.

Contest with George Chaffey in re his application for rights of way on Oak Creek.

Contest with George Chaffey in re his application for rights of way on Shepherd's Creek.

Contest with George Chaffey in re his application for rights of way on Independence Creek.

Contest with George Chaffey in re his application for rights of way on George's Creek.

Application of the City to purchase lands in the Long Valley Reservoir Site.

Application of the City to purchase lands in the Tinemaha Reservoir Site.

Application of the City to purchase lands in the Owens River Channel.

Application of the City to purchase water bearing lands in the Owens River Valley.

Contest with C. Howard Merritt in re his application for rights of way on Haiwee Creek.

Contest with C. Howard Merritt in re his application for rights of way on Hogback Creek.

Contest with the Round Valley Water Users' Association in re its application for rights of way on Rock Creek.

Contest with F. R. Smith in re his application for rights of way on Rock Creek. Compromise effected and application granted subject to the compromise agreement.

Contest with the Mono Power Company in re its application for rights of way on Owens River.

Contest with Gram and Anton in re their application for rights of way on Cottonwood Creek.

Contest with J. M. Taylor in re his application for rights of way on Owens River.

SUITS AFFECTING THE AQUEDUCT.

The City of Los Angeles vs. Daniel Curtis, et al. Superior Court, Los Angeles County. To condemn rights-of-way. Compromised and will be dismissed.

John F. Dickson vs. Fred Eaton, et al. Superior Court, Inyo County. To condemn rights-of-way. On demurrer.

Fairbanks-Morse & Company vs. City of Los Angeles, et al. Superior Court, Los Angeles County. To enjoin performance of contract. Action dismissed.

Horace S. Foutz vs. The City of Los Angeles, et al. Superior Court, Los Angeles County. Action for damages on account of personal injury. At issue.

E. R. Fox vs. A. A. Hubbard, et al. Supreme Court, State of California. Decision rendered in favor of the city.

Inyo Consolidated Water Company vs. Stoddard Jess, et al. Supreme Court, State of California. To quiet title to waters of Cottonwood Creek. On appeal.

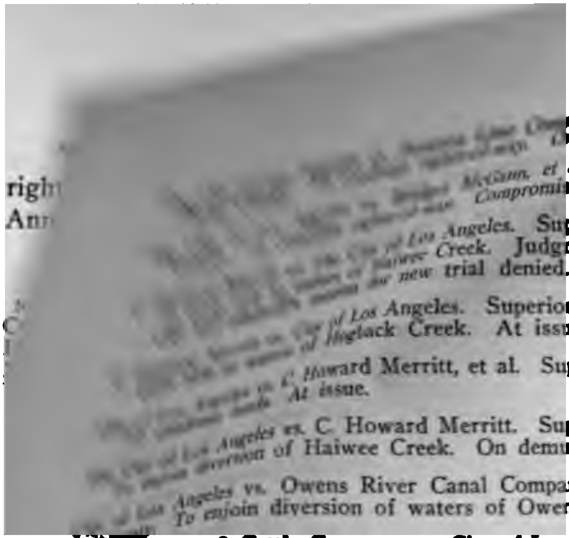
Inyo Consolidated Water Company vs. The City of Los Angeles, et al. Superior Court, Inyo County. To quiet title to waters of Lone Pine Creek. On demurrer to Third Amended Complaint.

Inyo Consolidated Water Company vs. The City of Los Angeles. Superior Court, Inyo County. To quiet title to waters of Oak Creek. Demurrer of City sustained and plaintiff given time to amend.

Inyo Consolidated Water Company vs. City of Los Angeles, et al. Superior Court, Inyo County. To quiet title to waters of Independence Creek. Demurrer of City sustained and plaintiff given time to amend.

Inyo Consolidated Water Company vs. City of Los Angeles, et al. Superior Court, Inyo County. To quiet title to waters of Shepherd's Creek. On demurrer to Third Amended Complaint.

Inyo Consolidated Water Company vs. City of Los Angeles, et al. Superior Court, Inyo County. To quiet title to waters of George's Creek. On demurrer to Third Amended Complaint.



Company, et al. *Superior Court,* On demurrer.

McGann, et al. Superior Court, *Inyo* Compromised and will be dismissed.

City of Los Angeles. Superior Court, Inyo County. Creek. Judgment rendered in favor of for new trial denied.

City of Los Angeles. Superior Court, Inyo County. To Hogback Creek. At issue.

C. Howard Merritt, et al. Superior Court, Inyo County. At issue.

Angeles vs. C. Howard Merritt. Superior Court, Inyo County. diversion of Haiwee Creek. On demurrer.

Angeles vs. Owens River Canal Company. Superior Court, Inyo To enjoin diversion of waters of Owens River. On demurrer.

Owens River Land & Cattle Company vs. City of Los Angeles. Superior Court, Inyo County. To quiet title to land. Decree in favor of plaintiff filed.

A. St. Clair Perry vs. City of Los Angeles, et al. Supreme Court, State of California. Decision rendered in favor of the City.

Silver Lake Power & Irrigation Company vs. City of Los Angeles, et al. Superior Court, Inyo County. To quiet title to waters of Owens River. On Demurrer to Amended Complaint.

Silver Lake Power & Irrigation Company vs. City of Los Angeles, et al. Superior Court, Mono County. To quiet title to waters of Owens River and other streams. On demurrer.

The City of Los Angeles vs. Jameson Lime Company, et al. Superior Court, Kern County. To condemn rights-of-way. On demurrer.

The City of Los Angeles vs. Bridget McGann, et al. Superior Court, Inyo County. To condemn rights-of-way. Compromised and will be dismissed.

C. Howard Merritt vs. The City of Los Angeles. Superior Court, Inyo County. To quiet title to waters of Haiwee Creek. Judgment rendered in favor of City and plaintiff's motion for new trial denied.

C. Howard Merritt vs. City of Los Angeles. Superior Court, Inyo County. To quiet title to waters of Hogback Creek. At issue.

City of Los Angeles vs. C. Howard Merritt, et al. Superior Court, Inyo County. To condemn lands. At issue.

The City of Los Angeles vs. C. Howard Merritt. Superior Court, Inyo County. To enjoin diversion of Haiwee Creek. On demurrer.

City of Los Angeles vs. Owens River Canal Company. Superior Court, Inyo County. To enjoin diversion of waters of Owens River. On demurrer.

Owens River Land & Cattle Company vs. City of Los Angeles. Superior Court, Inyo County. To quiet title to land. Decree in favor of plaintiff filed.

A. St. Clair Perry vs. City of Los Angeles, et al. Supreme Court, State of California. Decision rendered in favor of the City.

Silver Lake Power & Irrigation Company vs. City of Los Angeles, et al. Superior Court, Inyo County. To quiet title to waters of Owens River. On demurrer to Amended Complaint.

Silver Lake Power & Irrigation Company vs. City of Los Angeles, et al. Superior Court, Mono County. To quiet title to waters of Owens River and other streams. On demurrer.

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